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171—Journal Section of
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The wide variety of piping serving a new steel plant is described briefly on pages 166 and 167

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WELDING FITTINGS BY GRINNELL

WHEREVER **PIPING** IS INVOLVED

The Editor's Page

■ **Air conditioning** equipment sold by Carrier Corp. during the last two weeks of January called for the largest volume of refrigeration for any half month since 1937, President J. I. Lyle has announced. Mr. Lyle stated that the increase is encouraging as it came from sources which to some extent, he said, have been out of the air conditioning market since the abrupt business break in the fall of 1937—the large office buildings, department stores and process industries. . . . Central plant air conditioning systems sold in Chicago in January were more than double those reported in the same month last year, both in number and capacity, according to Commonwealth Edison Co. . . . A summary of air conditioning installations in Chicago compiled by Commonwealth Edison shows that at the end of 1938 there were 1730 central systems totaling 74,858 connected horsepower, plus 866 room coolers totaling 812 horsepower.

■ **C. V. Haynes** has retired from active duty with Hoffman Specialty Co., with which he has been identified for a period of about 20 years, but will remain as a director, President Potter Bowles announced last month. One of the best known figures in the heating business, he is a past president of the ASHVE. . . . The resignation as of March 1 of Guy Hutchinson, who has been vice president and general manager of Hoffman Specialty, has been announced. . . . A. B. Schellenberg, formerly vice president of the Alco Valve Co., was elected president and general manager at a recent meeting of the board of directors to succeed J. L. Shrode, who died suddenly December 31. During the past two years, Mr. Schellenberg has lectured on refrigerant control in over 50 cities in the United States and Canada and has addressed many engineering society meetings. . . . William P. Bradbury, vice president and general sales manager of the Consolidated Ashcroft Hancock Div., Manning, Maxwell & Moore, Inc., died of pneumonia after a six day illness January 14. Mr. Bradbury joined Manning, Maxwell & Moore in 1902 as an office boy and advanced step by step through various positions in the sales department.

■ **An example** of one phase of a forward looking public relations program is the explanatory financial report to the employees of Blaw-Knox Co. issued by President William P. Witherow. Prepared in a clearly understandable manner, the report discusses such topics as the ownership of the company, how the stockholders' investment creates jobs, presents an explanatory balance sheet, and describes how the income of the company is spent. . . . Particularly interesting are the average figures per employee. For instance, it is shown that there is an average investment of $7,237 for each job or employee in the Blaw-Knox organization. The idea is carried forward in a tabulation of income and expenditures where figures per employee as well as total amounts are given. In a summary of 1938 tax payments, the total is shown to amount to $132.32 per employee, while company profits were $53.39 per employee.

■ **A series** of radio discussions on heating and cooling is being given over the University of Illinois station WILL on Tuesday afternoons at 4:30. The first of the talks was given on February 7 and they are being continued through March by members of the teaching and research staff of the department of mechanical engineering. . . . WILL, which has been on the air since 1922, is a leading educational station and operates approximately 10 hours daily the year around on a frequency of 580 kilocycles.

■ **Benjamin Franklin's** wide range of interests included principles of air conditioning, in addition to his better known activities in improving heating equipment, his studies of electricity, and his other scientific work. In Carl Van Doren's new biography of Franklin, published by the Viking Press, his comments on and experiments with various psychrometric phenomena are mentioned several times. . . . For example, Franklin organized a discussion group or club, and one of the questions considered was "Whence comes the dew that stands on the outside of a tankard that has cold water in it in the summer time"—an illustration which is still used to explain how air is dehumidified by reducing its temperature below the dew point. . . . In a letter to a friend, Franklin described an experiment involving the wet bulb temperature. "Wet the ball of a thermometer by a feather dipped in spirit of wine which has been kept in the same room and has, of course, the same degree of heat or cold," he wrote. "The mercury sinks presently three or four degrees, and the quicker if during the evaporation you blow on the ball with a bellows; a second wetting and blowing when the mercury is down carries it yet lower. I think I did not get it lower than five or six degrees from where it naturally stood, which was at that time sixty," he concluded. He later conducted experiments on evaporation with John Hadley, professor of chemistry at Cambridge. . . . Absorption of solar radiation by different colored surfaces was another subject in which he interested himself. He placed squares of different colored pieces of broadcloth on the surface of the snow on a bright, sunny day, found that the black—being warmed most by the sun—sank the lowest into the snow, the other colors less the lighter they were, the white cloth not at all. From this, he concluded that black clothes are not so fit to wear in a hot, sunny climate or season as white ones. This was a century before Europeans had learned to wear light colored clothing in the tropics.

■ **The American Society** of Mechanical Engineers, 29 W. 39th St., New York, N. Y., has announced publication of an extensive revision of the standard covering steel pipe flanges and flanged fittings; the revision reflects changes which have taken place since issuance of the 1932 edition. . . . The ASME has also announced publication of a standard on face to face dimensions of ferrous flanged and welding end valves covering wedge gate, double disc gate, globe and angle, and swing check valves. . . . Because of a large number of developments in connection with its more than 100 specifications covering various types of steel and steel products, committee A-1 of the American Society for Testing Materials resumed its January meetings in Philadelphia this year; these meetings have been discontinued for the past several years. . . . Pronounced activity on the possibility of consolidating into one specification steels of somewhat similar classes and grades now covered in different standards is reported, and there was considerable interest in the work on pipe and tubing materials and materials for high temperature service. . . . One of the important actions taken was formation of a new section to concentrate on specification work for welding fittings.

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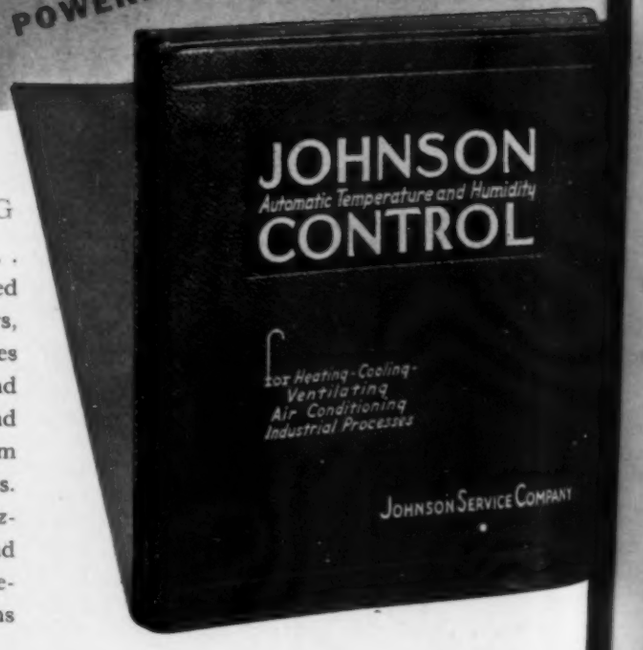

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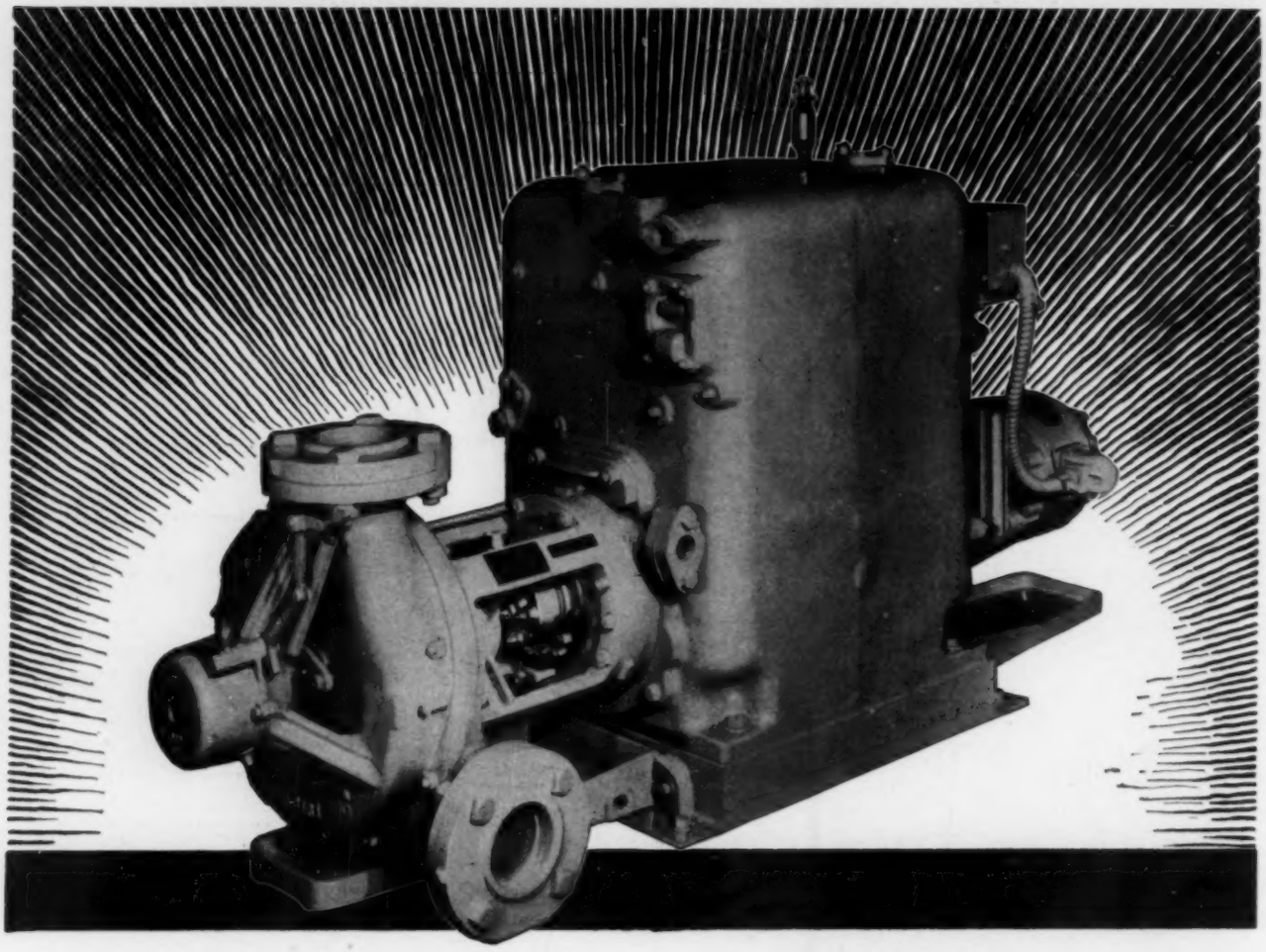

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Heating · Piping
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Vol. 11, *No.* 3 ● *March,* 1939

Fabrication Details for High Pressure and Temperature Piping

By Arthur McCutchan*

THE procedure used in welding carbon-moly pipe in an extension of the Delray plant and the need for preheating and stress relieving were described in two articles by Sabin Crocker which appeared in the January and February, 1939, issues of HEATING, PIPING AND AIR CONDITIONING. The present article is devoted to fabrication details used in the same extension of Delray and to the various changes and improvements in design which experience and investigations have shown to be desirable in future work.

A majority of the novel details developed in connection with the use of welded construction for the high pressure piping at Conners Creek[1] have been incorporated without change in the piping for Delray. Among such items are: (a) manifolds built up of pipe with welded branch connections; (b) flow nozzles welded into the line; (c) bypass, drip, and instrument lines attached to valves and pipe by fillet welds; and (d) socket welding fittings and couplings, etc.

Bypass and Drip Connections

The detail of attachment of bypasses, drips, etc., to valve bodies and large pipe shown in Fig. 1 has been described in previous articles[1,2] but its advantages are so pronounced that it is deemed worth repeating here. In addition to affording a simple and generally satisfactory attachment, the thousands of welds of this type now in service give ample proof of the fact that light-walled pipe can be welded successfully to much heavier sections. While it is considered desirable to have the thickness of parts joined by welding equal, or not too greatly different, it is apparent that this requirement is not as essential as was at first thought.

Thermocouple and Thermometer Wells

Fillet welds also have been used to advantage in installing thermocouple and thermometer wells in steam and boiler feed lines. The first welded thermocouple wells were adapted from existing threaded designs and the method of locating the well on the pipe and the welding procedure were essentially the same as used for bypass and drip connections. The sharp corners of the finned well used for superheated steam, possibly inadequate section, and 150 F higher temperature than previously used with this design resulted in one of the wells breaking off inside the pipe. After the broken end was retrieved from the throttle valve strainer where it had lodged, examination of the parts showed that failure had occurred through fatigue.

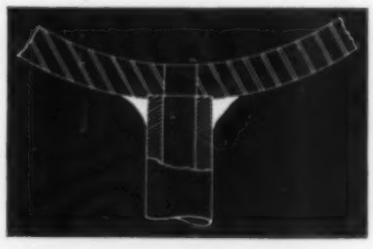


Fig. 1—Method of attaching bypass and drip lines

Although the hole in the thermocouple well was less than ⅜ in. in diameter, the noise and disturbance occasioned by 650 psi (lb per sq in.), 850 F steam shooting out into the room left no doubt as to the need for extreme caution in attaching such appendages to high pressure, high temperature steam lines.

In re-designing these wells a chrome-silicon-moly material was substituted for SAE 1025 carbon steel, and fins and all sharp corners were eliminated. The final design shown in Fig. 2 is extremely rugged and in all

Carbon-molybdenum steel is being used for the 865 lb, 910 F steam piping in the extension of Detroit Edison's Delray Station, and in the January and February issues of HEATING, PIPING AND AIR CONDITIONING, Sabin Crocker reported on experience in welding this piping material. . . . This month, Arthur McCutchan discusses fabrication details adopted for this piping, and will continue the subject in a second article which will cover re-design of ring reinforcement and the method of beveling welded branch connections to permit using contoured backing rings

*Engineer, Engineering Div., The Detroit Edison Co.

[1]See list of references on p. 21, HEATING, PIPING AND AIR CONDITIONING, January, 1939.

[2]"Dripping High Pressure, High Temperature Steam Piping," by Arthur McCutchan, HEATING, PIPING AND AIR CONDITIONING, August, 1938, pp. 501-503.

probability would be satisfactory if made of carbon steel. The alloy steel gives an added factor of safety, however, and since it is purchased in the annealed condition, it eliminates the local heat treating required with the SAE 1025 steel. The extra cost of the alloy material, taking this saving in local heat treating cost into account, is not significant.

The relatively high resistance of this chrome-silicon-moly material to the action of steam at 1100 F[3] indicates that little scaling need be anticipated at the service temperature of 910 F at Delray. A thermocouple well of this material examined after 4000 hr at 850 F in a boiler lead at Conners Creek showed very slight scaling. Our experience with machining and welding this alloy material has been entirely satisfactory. A chrome-manganese silicon electrode has been found suitable for welding this material to both carbon steel and to carbon-moly pipe.

Backing Rings

The purpose of a backing ring is to permit separating the pipe ends sufficiently to enable the welder to penetrate to the inside of the pipe wall without getting weld spatter and icicles inside the pipe. Backing rings also are of assistance in aligning the pipe ends and may be provided with ridges, pins or tapered surfaces to give the desired separation of the pipe ends.

Ideas as to what constitutes suitable backing rings have fluctuated between two extremes during the past few years. As one extreme, pipe ends have been upset and counterbored to receive continuous rings which were completely recessed in the pipe wall. This upsetting operation was expensive and in some cases so difficult that the expedient of building up the pipe ends with weld metal has been used. As the other extreme, relatively heavy sectioned split rings, 2 in. wide and ⅛ in. to ¼ in. thick, depending upon pipe size, were simply sprung into position and fitted as closely as possible to the inside diameters of the abutting pipe ends. This type of split backing ring was used at Conners Creek and for the first part of the Delray extension. (See Fig. 3.)

While there is every indication that these backing rings fulfilled their main purpose, variations in inside diameter of the pipe, lack of roundness of pipe ends, etc., made it difficult in some instances to secure a satisfactory fit. This condition was aggravated in the case of the Schedule 100 carbon-moly pipe used at Delray. In several instances it was necessary to machine special offset backing rings to accommodate the large variation in diameter of abutting pipe ends. Apparently carbon-moly pipe is more difficult to manufacture to close tolerances than carbon steel. In this connection it might be noted that manufacturing tolerances on pipe have always been applied to the outside diameters and wall thicknesses, hence there has been no special effort to control the inside diameters. With the wide adoption of welding for high pressure, high temperature, pipe lines, it seems logical that definite tolerances should be specified for the inside diameters, possibly allowing greater variations in the outside diameters if found necessary.

The trend at Detroit Edison is toward using lighter backing rings, ⅛ in. thick and approximately ¾ in. wide, which are partially recessed in the pipe wall. In truing up the bore of the pipe ends for these partially recessed backing rings, advantage is taken of the extra thickness usually present in high pressure pipe. This extra thickness over the minimum required for the particular pressure and temperature conditions can be removed without encroaching on safety requirements. The usual under-thickness tolerance in manufacture is 12½ per cent below the nominal thickness, which on a full nominal thickness 8 in. and larger diameter Schedule 80 pipe might leave from 1/16 to ⅛ in. of the wall available all around for removal in the counterboring operation. On a pipe end of over nominal thickness still more surplus material would be available for countersinking the backing ring. In the case of welding end valves, of course, plenty of surplus metal can be provided for recessing the backing ring.

In adopting partially recessed backing rings of small section for *high pressure* piping, Detroit Edison engineers were favorably impressed with the idea of slightly tapering the rings as proposed by F. C. Fantz in his paper[4] presented before the western regional conference of the American Welding Society in March, 1938. When tapered rings of this sort were tried out in making qualification tests where results could be observed conveniently after the welds were sectioned into test strips, it was found that the tapered rings continued hugging the pipe bore closely instead of springing away due to contraction of the weld metal in cooling as was the case with flat rings. (See Fig. 4.) Accordingly, it was decided to adopt a continuous ring (as distinguished from a ring

[3] "High Temperature Steam Experience at Detroit," by R. M. Van Duzer, Jr., and Arthur McCutchan, paper presented at annual meeting of ASME, December, 1938.

[4] "Design and Fabrication of High Pressure, High Temperature Welded Piping," by F. C. Fantz, abstracted in HEATING, PIPING AND AIR CONDITIONING, May, 1938, pp. 329-332.

Fig. 2—Thermocouple well for high temperature service

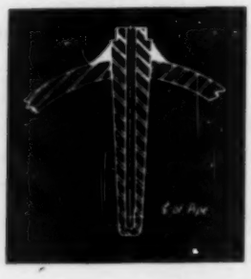
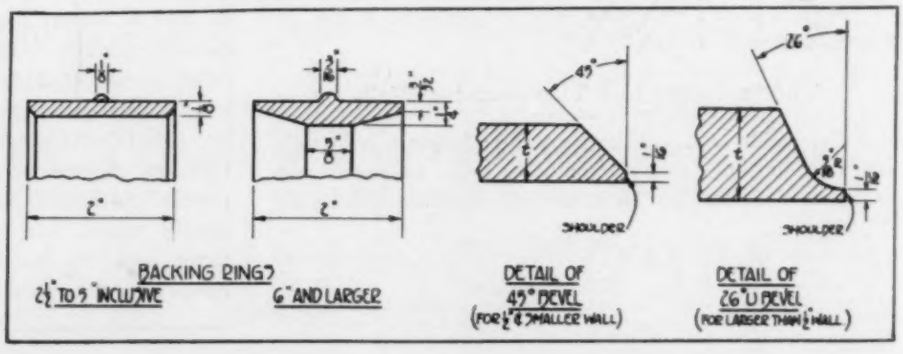


Fig. 3—Backing rings and details of welding bevels used in first section of Delray extension



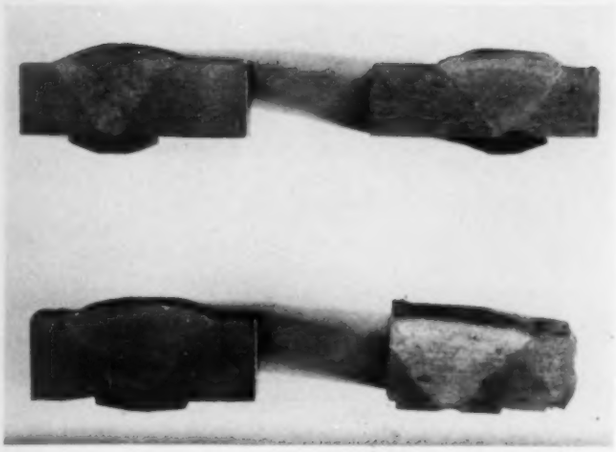


Fig. 4—Sections of welds showing effect of weld contraction on fit of flat and tapered backing rings

split like a piston ring) made with a 10 deg taper and otherwise of the design and shape shown in Fig. 5.

In establishing the outside diameter of the continuous backing rings (dimension "E" of the sketches and table reproduced in Fig. 5) it was assumed that the outside diameter of the pipe would be a mean of the permissible variations under and over the nominal and that the underthickness tolerance on the pipe wall would be 8 per cent rather than the extreme of 12½ per cent permitted in the specifications. These assumptions were based on measurements of the diameter and wall thickness of several hundred lengths of seamless steel pipe. Where maximum permissible deviations from nominal dimensions are encountered, the split type of flat backing ring also shown in Fig. 5 will be used. This flat ring with ¼ in. spacing pins has been developed for Schedule 40 and lighter wall pipe. Quite satisfactory welds can be made with this ring, although the appearance of the weld cross section is not as good as with the tapered ring since contraction of the weld pushes the ring away from the pipe wall to some extent.

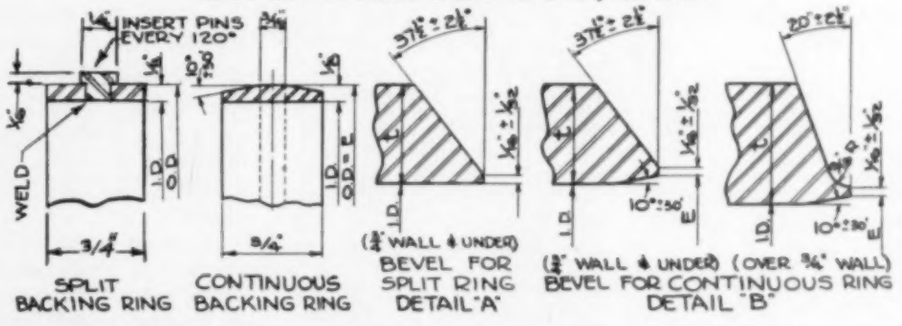
The reduction in width of backing ring from the 2 in. width previously used to ¾ in. is not considered to have any particular effect on the already insignificant pressure loss chargeable to backing rings in pipe sizes 6 in. and larger, but it enables the same rings to be used with welding elbows, tees, etc., which, with the narrow ring, need be sized for only about ⅜ in. at the ends. The reduction in thickness of the rings for pipe sizes 6 in. and larger from ¼ in. to ⅛ in. and the partial recessing of the tapered rings should give some improvement in flow conditions.

Welding Bevels

The preparation of pipe ends for welding has an important bearing on the quality of the joint and on its cost. While it is possible to make satisfactory welds with rather widely different types of welding bevel—as evidenced by the multiplicity of designs developed by the different industries using pipe—the complication of stocking pipe, valves, and welding fittings with different types of bevel was undesirable. Accordingly, a subgroup of ASA sectional committee B16 was appointed to study existing bevels and to recommend bevels suitable for standardization. The types of bevel recommended by this subgroup, which are shown in Fig. 6, have been adopted as "recommended practice" by sectional committee B16.

For thicknesses 3/16 to ¾ in. inclusive, the new recommended practice prescribes the 37½ deg, ± 2½ deg,

Fig. 5—Backing rings and details of welding bevels to be used in second section of Delray extension



Nominal Pipe Size	A S A Schedule Number, Pipe	Nominal Outside Diameter, Pipe	Nominal Inside Diameter, Pipe & Fittings	Nominal Thickness of Pipe & Fittings t	Backing Rings			
					Continuous		Split	
					Nominal Outside Diameter E	Nominal Inside Diameter	Nominal Outside Diameter	Nominal Inside Diameter
2½	40	2.875	2.469	0.203			2.469	2.219
2½	80	2.875	2.323	0.276	2.367	2.117	2.323	2.073
2½	160	2.875	2.125	0.375	2.185	1.935	2.125	1.875
3	40	3.500	3.068	0.216			3.068	2.818
3	80	3.500	2.900	0.300	2.948	2.698	2.900	2.650
3	160	3.500	2.626	0.437	2.696	2.446	2.626	2.376
4	40	4.500	4.026	0.237			4.026	3.776
4	80	4.500	3.826	0.337	3.880	3.630	3.826	3.576
4	120	4.500	3.626	0.437	3.696	3.446	3.626	3.376
6	40	6.625	6.065	0.280			6.065	5.815
6	80	6.625	5.761	0.432	5.846	5.596	5.761	5.511
6	120	6.625	5.501	0.562	5.607	5.357	5.501	5.251
8	40	8.625	7.981	0.322			7.981	7.731
8	80	8.625	7.625	0.500	7.721	7.471	7.625	7.375
8	100	8.625	7.439	0.593	7.550	7.300	7.439	7.189
10	40	10.750	10.020	0.365			10.020	9.770
10	80	10.750	9.564	0.593	9.690	9.440	9.564	9.314
10	100	10.750	9.314	0.718	9.460	9.210	9.314	9.064
12	Std. Wt.	12.750	12.000	0.375			12.000	11.750
12	40	12.750	11.938	0.406			11.938	11.688
12	80	12.750	11.376	0.687	11.517	11.267	11.376	11.126
12	100	12.750	11.064	0.843	11.230	10.980	11.064	10.814
14	30	14.000	13.250	0.375			13.250	13.000
14	40	14.000	13.126	0.437			13.126	12.876
14	80	14.000	12.500	0.750	12.651	12.401	12.500	12.250
14	100	14.000	12.126	0.937	12.307	12.057	12.126	11.876
16	30	16.000	15.250	0.375			15.250	15.000
16	40	16.000	15.000	0.500			15.000	14.750
16	80	16.000	14.314	0.843	14.480	14.230	14.314	14.064
18	Std. Wt.	18.000	17.250	0.375			17.250	17.000
20	20	20.000	19.250	0.375			19.250	19.000
24	20	24.000	23.250	0.375			23.250	23.000

(All dimensions are given in inches)

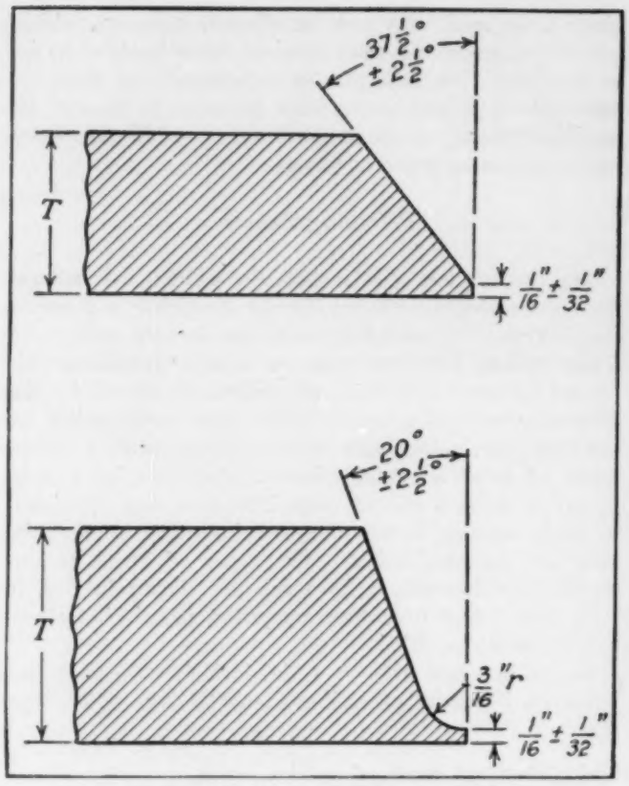


Fig. 6—Welding bevels adopted as "recommended practice" by ASA sectional committee B16

Fig. 6a (above)—Standard straight bevel of welding ends for thicknesses T ⅜ to ¾ in., inclusive.
Fig. 6b (below)—Standard U-bevel of welding ends for thickness T greater than ¾ in. This form of bevel is not recommended for acetylene welding and may be changed to straight bevel as in Fig. 6a.

straight bevel standardized by the American Petroleum Institute some time ago. This differs from the 45 deg bevel heretofore used by other branches of the piping trade. See Fig. 3.

For thicknesses over ¾ in. the recommended practice for arc welding calls for a 20 deg, ± 2½ deg, U-bevel with 3/16 in. radius at bottom of bevel as shown in Fig. 6. While this gives a narrower groove than the 5/16 in. radius, 26 deg U-bevel previously used by Detroit Edison, trial qualification welds have demonstrated that it is entirely satisfactory.

It is contemplated that eventually these recommended bevels will be furnished as standard on pipe, welding neck flanges, welding fittings, valve bodies and the like unless otherwise specified by the purchaser. In the meantime, sufficient leeway will be allowed to use up existing stocks of material having different bevels.

In applying the tapered backing ring, it is necessary to true up the bore of the pipe ends by machining or reaming the ends to give a 10 deg taper as shown in Fig. 5. In all other respects, the preparation of the pipe ends conforms to the "recommended practice" for welding bevels.

The welded branch connection and pipe-to-valve weld shown in Fig. 7 give a good idea of the finished appearance of the welds. It may be noted that no undercutting exists at the edges of the welds and that there is a gradual transition from the header thickness to the combined thickness of the header and ring reinforcement.

Fig. 7—Ring reinforced welded branch connection and pipe-to-valve weld

An investigation made of the stress conditions in a full size welded branch connection employing the same method of preparation,[5] welding, and reinforcement as that used at Delray demonstrated the adequacy of this design as far as ultimate bursting pressure was concerned.

[A second article by Mr. McCutchan will cover the re-design of the ring reinforcement in the light of the above investigation and will describe the reasons for changing the method of beveling welded branch connections to permit the use of contoured backing rings.]

[5] "Investigation of Stress Conditions in a Full-Size Welded Branch Connection," by F. L. Everett and Arthur McCutchan, ASME *Transactions*, July, 1938, FSP 60-12, pp. 399-410.

The academic work of students in air conditioned schoolrooms is being tested and compared in actual practice with that of students in non-air conditioned schoolrooms in an experiment being conducted by the Venezuela ministry of education.

Twelve classrooms in a new primary grade school in Caracas erected by the ministry of public works were air conditioned. The air conditioned rooms have glass brick panels in place of windows, while regular classrooms have standard windows. The ministry of education hopes to determine the best possible atmospheric and light conditions as a standard for future school systems.

Preliminary reports indicate that children in the air conditioned rooms are showing greater concentration and interest in their work, less fatigue and miss less schoolwork because of illness, according to Carrier Corp. With a more uniform amount of light in the rooms, eye strain has been reduced and reading made easier.

Modern Illumination Presents Problems for Air Conditioning Design to Solve

By Samuel R. Lewis*

THE air conditioning engineer probably owes most of his living to the illuminating engineer. Of course, solar energy, radiation from the bodies of the occupants, and moisture control have something to do with the excuse for living of the air conditioning engineer, but if all areas in rooms were close enough to windows so that solar light only was necessary, and if they were occupied only during daylight hours, there would be very much less ventilating and heat removing business for the air conditioning engineer.

Interest in the relation of illumination of buildings to air conditioning is increasing, and in January the Chicago chapter of the Illuminating Engineering Society devoted its regular meeting to the subject. The speakers were Mr. Lewis, whose address is published here, and Walter Sturrock, who gave data on heat from various types of fixtures and methods of removing it[1]. . . . In his introductory remarks, the chairman of the meeting said that "modern lighting of high intensities gave birth to air conditioning." While the illuminating engineer can hardly take the entire credit for air conditioning (for it might be said that air conditioning has made possible modern high intensity lighting) there is a close relationship between the two services which must be considered carefully by the air conditioning engineer and the illuminating engineer, as Mr. Lewis shows in his paper

It appears from the records in most cities that restaurants and apparel shops at the moment predominate in their demand for comfort cooling, and that these places require it because generally they occupy quarters having so little natural light that they would be useless even at high noon unless electric lights were employed. Given electric lights, however, so small is the exposed wall and glass area available for transmitting surplus heat out-of-doors (in most restaurants and apparel shops) that powerful mechanical ventilation becomes necessary. In many cases this ventilation must be supplemented by refrigeration even during comparatively cool weather.

Electric illumination serves civilization by rendering useful many spaces which otherwise would be unusable, and co-ordinates with air conditioning to make these spaces habitable, attractive and healthful. Frequently, however, after the air conditioning engineer has made a cooling installation in an existing room where the surplus heat was removed admirably, the owner sends for the illuminating engineer, who proceeds to install more brilliant illumination, often doubling and tripling the heat input and overloading the air conditioning facilities. Too frequently, in the estimation of the air conditioning fraternity, the illuminating engineer sells fixtures and wiring and energy without paying the slightest attention to the amount this additional energy may cost the owner in discomfort due to overheating and in dollars for more air ducts and refrigeration and power.

The illuminating engineer not infrequently installs his lighting equipment in spaces so hot that insulation deteriorates and filaments burn out and the owner suffers unnecessarily high maintenance and energy charges. Had the illuminating engineer a better contact with air conditioning he might have made a happier client had he issued warnings to the owner against reckless increase in wattage without commensurate increase in heat removal capacity.

The air conditioning man also has been at fault, since his tendency under stress of competition may have been to count the light bulbs or read the demand meter and to base his load on that data, paying no attention to the lighting. He should have noticed lighting so deficient that a little illuminating common sense would have made him win the affection of the owner by suggesting some attention to new wiring and fixtures and distribution. In most air conditioning installations in existing rooms the alterations necessary for installation of new ducts and piping very well should accommodate also some new conduits and fixtures.

The air conditioning engineer is taught to measure the heat gain for every room meticulously. He figures every square foot of heat transmitting wall, window, ceiling, floor, etc. He allows for sunshine and wind. He estimates carefully the maximum number of occupants and figures the number of pounds of perspiration each can be expected to disseminate. He may figure that the cool surface of the drinking water urn will counterbalance the warm surface of the coffee urn, and he finds out how much gas is to be burned. Then he guesses perhaps 2 watts per sq ft of floor for illumination and thinks that he has done well. He may not realize that in guessing at this major item he may abrogate the necessity for accurate computation of all the minor items of his heat balance. In many cases, however, the owner—without thinking about it, or consulting the air conditioning man—will be sold lighting fixtures which shed 6 or 8 watts per sq ft of floor per hr, and which will develop potentialities of a lively row for next August concerning guarantees of cooling capacity.

Here are the actual heat removal demand figures in Btu per hr for one commercial installation in a department store basement based on summer conditions:

Heat gain through walls and ceiling	22,000
Heat gain due to air leakage	none
Heat gain due to 100 salespeople and customers	38,000
Heat gain in cooling the air required for ventilation	52,000
Heat gain due to electric illumination	95,000
	207,000

*Consulting Engineer. Member of Board of Consulting and Contributing Editors.

[1]See Effects of Artificial Lighting on Air Conditioning, by Walter Sturrock, ASHVE *Journal Section*, HEATING, PIPING AND AIR CONDITIONING, February, 1938, pp. 134-144.

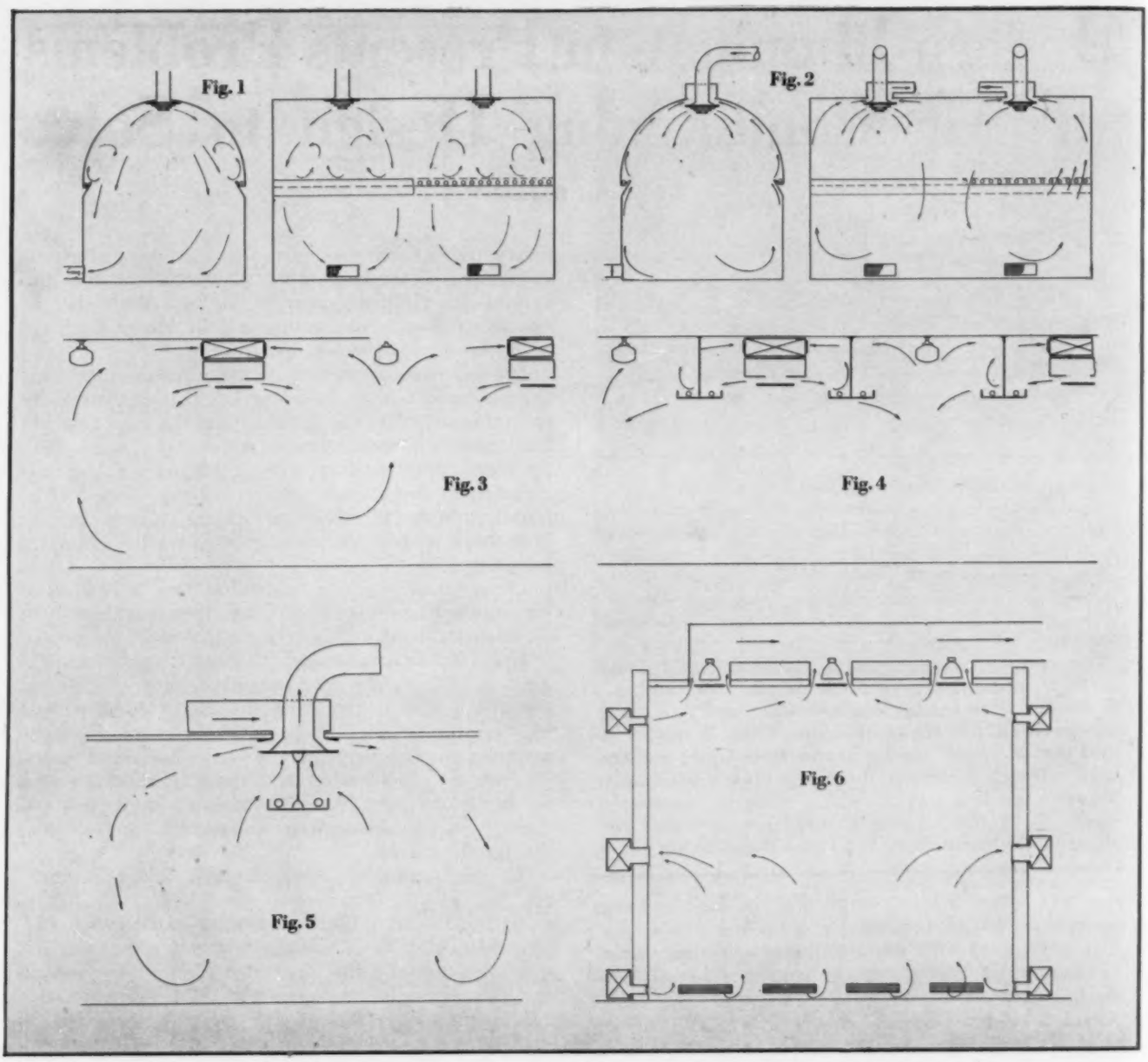


Fig. 1—Directors' room showing how lights warmed the entering cooled air. . . . Fig. 2—Same room after air circulation was revised so that entering cool air was no longer blown against the lamps. . . . Fig. 3—Drafting room showing original lighting fixtures. . . . Fig. 4—New lighting fixtures installed in the same drafting room, showing how the entering cool air fell into them and was heated. The situation was corrected by moving the air supply inlets so that they could not deliver the cool air into the lighting bowls. . . . Fig. 5—Scheme for air introduction and removal in combination with illumination which has proved satisfactory in many rooms. . . . Fig. 6—Proposed scheme for air circulation and lighting in an art gallery, using two air systems

In this case, which is by no means extraordinary, the illumination load is 46 per cent of the total; 95,000 Btu per hr is the equivalent of about 400 sq ft of steam radiation. The room is heated electrically by the lights even in cold weather. Such a room always requires admission of air at a temperature cooler than that in the room. In this instance a ventilating and cooling system installed several years ago was based on existing illumination of around 18,000 watts, which was stated by the owner, an experienced and successful merchant, to be ample. The comfort developed by the plant increased the business, and thereupon all of the display counters and cabinets were modernized, and new high power lights were installed. Many of these are spot lights recessed between the joists with lenses flush with the ceiling. The owner is now investing something like $6000 more to increase the refrigerating and ventilating facilities so as to remove the surplus heat from the increased illumination.

Perhaps in this case the logical course of events could not have been foreseen or prevented, but I am called on all too frequently to straighten out situations in which a reputable contractor backed by a reputable manufacturer agreed to cool a room. The contract did not state the agreed number of occupants, the number or size of heat producing appliances, or the wattage of illuminating fixtures. The owner testifies that he said "There is the room, tell me how many dollars you want for cooling it to 80 deg and for maintaining 50 per cent relative humidity." The contractor bids against perhaps ten other

"suckers" and sews himself securely into a contract based on say 4 watts per sq ft of floor. The owner then, without telling anyone, fills his show cases with continuous lights, spots floodlights all over the ceiling, lines the hood over the sandwich bar with big inefficient light bulbs and pays for perhaps 10 watts per sq ft of floor.

The air conditioning contractor of course should guarantee nothing whatever about heat removal unless the contract limits the heat input which is to be removed. Almost invariably the owner thinks that payment of a high monthly rate for energy in ordinary bulbs is better business for him than to pay a higher first investment for more efficient lamps and more perfect diffusion.

The public service companies are good business men. They know that in the long run it is preferable to sell less energy to a contented owner with efficient illumination than to sell more energy to an unhappy owner. The air conditioning engineer perfectly well knows that an incandescent bulb is a hot bulb. It will char and ignite paper which touches it. Yet we find him going to great trouble and expense to install a refrigerated air ventilating system with its elaborate ducts and grilles and thermostats, and then arranging so that this air first touches and is heated by great banks of hot electric light bulbs before by any chance it can reach the sweltering people in the room.

Lighting Affects Heat Control

In an Iowa school building it is proposed by an optometrist specialist member of the board of education that there shall be provided six 750 watt lamps for every standard classroom, or 6 watts per sq ft of floor area. This is more than double the usual school classroom allowance. If this wattage is consumed, the heat input will be equivalent to 65 sq ft of steam radiation, more than one-third enough to heat the room in sub-zero weather. The heating and ventilating engineer has a hard task to prevent overheating a school room during most of the time, since enough steam radiation must be installed to heat the room in the very coldest weather, and the very coldest weather occurs only for short and infrequent periods. The radiator supply valves can be shut in mild weather, but even so the interior temperature often becomes too warm. The heat removal from 65 sq ft of radiation which cannot be responsive to any control except that of light intensity is a tough proposition to tackle. In this connection of course we all realize that an air cooling and humidity controlling system is badly handicapped if there is no heat regain from the room available for expanding the cool, nearly saturated, entering air. This angle of heat from electric illumination is never forgotten by the air conditioning man, but its availability definitely is limited.

One successful proprietor of a great chain of cooled restaurants believed, until I showed him better, that the waste spent air from an artificially lighted and crowded restaurant positively must leave the room at the floor line. Surprisingly, by no means all air conditioning engineers have learned even today that it is entirely feasible and satisfactory in cooling a room to bring the cool air in near the top of the room, to allow it to settle down around the occupants, and then as it picks off their heat, to rise and to depart near and around most of the hot electric lights.

Two Air Systems for Intensely Lighted Rooms

I advance seriously the suggestion that we have arrived at the time for designing two separate ventilating systems for many a large intensely lighted room. One of these systems introduces air at say 60 deg, not too far above the heads of the people, and removes it at say 80 deg at a level somewhat higher than the inlets. This air returns to the apparatus for recirculation and dilution with some percentage of new air from outside. The second ventilating system in this room, taking intelligent use of the tendency of air to stratify, introduces new air from out-of-doors mixed with some part of the 80 deg air so as to be warmer than say 85 deg and exhausts it around or near the lights; this hot air never re-entering the room. When it is realized that a room 30 by 100 ft, having 3000 sq ft of area, requires an investment of something like $6000 for air conditioning, and an operating cost of perhaps $500 per year, this scheme for conservation of natural resources is by no means fantastic.

On the side of the illuminating engineer, he will be able to sell modern lighting equipment at greatly increased investment cost and installation profit if he realizes its potentialities in the light of air conditioning investment and operating costs.

Anyone who thinks must sympathize with the well meaning and honest public service company which under the conditions I complain about may sell more electric energy to make better illumination so that it can sell more electric energy to make refrigeration and operate fans so as to remove the heat from the electric energy it sells for illumination.

Every air conditioning engineer is intensely interested in the development of more light from less "juice." From all we can learn, a low priced electric light assembly wastes electricity, and wasted electricity means excess heat which somehow must be removed. In one recorded case in a lofty room with the old 1000 watt lamps consuming 2 watts per sq ft of floor the lighting intensity was less than 1 foot-candle. With modern reflectors at the same height and with only 1½ watts per sq ft of floor the intensity was brought up to 13 foot-candles. In other words the air conditioning system in the first instance was asked to remove 3450 Btu per effective foot-candle, and in the second case this was reduced to about 200 Btu per foot-candle.

Some Examples

Directors' Room—Fig. 1 illustrates the directors' room of a large corporation. The cooled air entered through two circular diffusers at the ceiling. The ceiling was of dark paneled and carved wood. The two light troughs had sixty-four 40 watt bulbs, giving off heat equivalent to 36 sq ft of steam radiation which warmed the air far more than did the bodies of the eight or ten portly old directors. They thought that the noonday sun, which could not look in through the windows at that hour anyway, must be overheating the air, so they installed heavy curtains and used all the lights, at full blast, in order to see their documents.

The situation was corrected with reasonable satisfaction by closing the vent outlets at the floor, by lowering the diffusers enough to permit exhausting the hot air around their tops, and by installing deflectors inside the

diffusers so that the entering cool air was no longer blown against the lamps, but so that the cool air after being diffused longitudinally could react upwards along the walls, pick up heat from the lights and hot ceiling and escape through the annular outlets above the inlet diffusers (see Fig. 2). The architectural design of the room of course was unfortunate. A white or nearly white ceiling would have permitted a great reduction in wattage without any decrease in light intensity. Had it been practicable to introduce the cool air along the sides of the room through a number of low velocity diffusers, with the outlets in the ceiling above the excessively hot lights there would have been no trouble.

Drafting Room—In a large drafting room the design wattage was about 4 watts per sq ft of floor. Overhead air cooling and ventilating ducts were installed after the manner of Fig. 3. They operated successfully for several years, when the owner discovered that more light was desirable. The original fixtures were close to the ceiling, were of the partially enclosed type and such heat as they gave off was very effectively removed by the spent air on its way out, as suggested in Fig. 3. However, the illuminating engineer and the owner very enthusiastically embraced the idea of reflected indirect illumination, and installed a great lot of indirect lighting fixtures, each having four 100 watt bulbs, somewhat after the manner of Fig. 4. The fixtures were beautiful chromium plated things like round bath tubs or shallow dish pans, and if one stands on a ladder and views them from above, the radiant heat from each one reminds him of that from the old red hot cannon stove in the small-town railway station. The rectangular diffusing plates of the cool air supply system were symmetrically disposed at the bay centers and altogether too many of the new lighting fixtures happened to come just where the cool air must fall into them. The result is suggested in Fig. 4, and when the draftsmen's production efficiency gained from the better light was lost due to perspiration falling on the tracings, the owner wished he had insisted on collaboration between the illuminating engineer and the air conditioning engineer.

The answer in this case was, of course, to move the air supply inlets so that they could not deliver cool air into the lighting bowls, since the inlets need not necessarily be on bay centers, and to move the spent air outlets so that they came above the lighting bowls. This was found to be an excellent case for automatic electric eye control, since the drafting room had daylight on three orientations, and since the draftsmen were too busy to bother about reducing the wattage when its use was unnecessary. The ceiling of this room was badly messed up with the air ducts, with heavy beams in both directions, and with many shadow-forming pipes and conduits. Had the illuminating engineer demanded a smooth, light reflecting, suspended ceiling the owner gladly would have provided it, and the same foot-candles would have been obtained with much reduced wattage and correspondingly reduced operating cost for air conditioning.

Fig. 5 shows a scheme for air introduction and removal in combination with illumination which has proved satisfactory in many rooms. It is based on the reasonable and well proved hypothesis that rooms which have no material heat loss through walls require cooling to at least a limited extent the whole year around. This indicates that I have been groping toward the idea of taking advantage of the tendency of air to stratify in response to differences in temperature. In Fig. 5, the entering cool air is above the departing warmed spent air. The entering cool air has little chance to absorb heat from the lighting fixture, falls down to the occupied zone, rises after cooling the people, assisted by the heat from the lights, and escapes vertically above the lights. There is no appreciable short circuiting between the air inlet and the air outlet.

Art Gallery—Fig. 6 is a cross section through an art gallery. I have not yet been allowed to build this job, but the next art gallery I do will be done in this manner. The coolest air will enter all the way around the room at exceedingly low velocity, directly at the floor. This might not answer in a classroom or in a parlor but it serves splendidly, as I have proved, in an art museum. It is exhausted at about the 8 ft level before it has had time to pick up the heat from the tremendous electrical energy involved by the batteries of lamps above the skylights. Air at about 85 to 90 deg enters near the ceiling and is exhausted through the skylights and around the lamps, keeping them comparatively cool and prolonging their useful service.

I realize of course that in the foregoing discussion of light and heat I have ignored radiant heat from the lamps, which goes with any direct light. The walls, furniture and floor which are able to "see" the light source directly will absorb a very appreciable amount of heat from this light. The air traversed by light receives practically no heat, and becomes warm only by convection as it rises around the substances which have absorbed radiant heat (or is blown against them).

Automatic Control of Lights

There is apparently considerable argument about the proper method of installing the new automatic illumination control governed by an electric eye. One argument is for the eye, when installed in a room having windows on one side only, to control the lights on the side of the room most remote from the windows. Then when sunlight wanes the inner lights will come on, and attention will be called to the probable necessity for turning on the outer lights. This may seem to be a reasonable proceeding. It seems fair to consider that the illumination on the darker side of the room should have the most particular care.

Other intelligent and experienced people may prefer that the electric eye shall turn on or off the lights in the outer and presumably better sunlighted zones. Here the response by the eye to changes in solar light intensity will be immediate, and when the outer lights are bright they will supplement the sunlight going to the inner zones and the latter may not need its own lights for some time after the outer zone has gone into service. The proponents of the first argument reply: If the eye controls only the outer zone, the lights of the inner zone will be burning all of the time and the energy lost will be high. One deduces that following Nature, which gives most of us two eyes, there should be complete automatic illumination control, with two electric eyes, one for the outer zone and one for the inner zone. This may not be economical so far as the cost of electric energy is concerned, but it probably will conserve the eyesight of the next generation.

How a Pioneer Skyscraper Has Obtained Heat Economy

By Rex E. Hieronymus*

Built back in the 1890's, the Monadnock building had no means of automatic control for its heating system. When the old hydraulic elevators, which had been driven by steam pumps, were replaced a few years ago with modern electric elevators, the matter of economy in steam utilization became important—for byproduct steam was no longer available and heating costs became governed solely by heating requirements and not by the requirements incidental to elevator operation . . . A thorough study of the heating was made, portable recording thermometers being used to determine the building temperatures maintained. New boilers, stoker equipped, were installed to promote efficiency in steam generation and a novel machine switching mechanism was devised to turn steam on and off to the four heating system zones. . . . The author describes the study, the improvements, and the results of the program

MODERNIZING the operation of the heating system of an old building which is obsolete in its most important elements is a hard problem. Among the primary requisites of a modern system are a pleasing type of radiation; if the building be large, some sort of zoning system related to vertical division or to exposure or both; and some effective method of control.

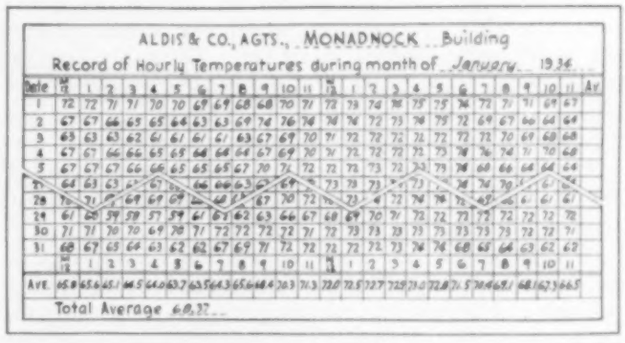
The Monadnock building, Chicago, built in 1892-93, offered the usual problems in this respect. In 1929 the problem of improving the performance of the heating system was actively taken up, as a study of the steam consumption and the temperature conditions in the building revealed that improvement was both possible and necessary.

This building was equipped with 51,000 sq ft of cast iron radiation of the 1890 period, operated as four separate Paul units,[1] the heating system being divided into four separate vertical divisions each 66 ft wide (the width of the building) by 100 ft long, the total length of the building being 400 ft. No means of automatic control had ever been provided, and any control exercised over temperatures was done by varying the steam pressure to the system feed, or by turning off the steam for long or short intervals depending on the weather. In mild weather, great inequalities in temperature prevailed throughout the building because it was difficult to obtain full circulation without overheating the upper parts of the building, for the systems were all down-fed from the attic distribution.

Prior to 1928 close control of the heating steam was not so important, for up to that time 16 hydraulic elevators driven by steam pumps were in use and except in the very coldest weather there was always an excess of exhaust steam available for space heating. With the change-over to modern, high speed electric elevators the close control of heating steam became profitable, for byproduct steam was no longer available and the heating costs were governed solely by the requirements for heating and not by the requirements incidental to elevator operation. At about this same time the 12 original steam boilers, which were worn out and obsolete, were replaced by four 125 hp scotch marine boilers operating at 100 lb pressure. They were originally installed for hand fired operation, and very shortly one of them was equipped to burn oil.

*General Superintendent for Aldis & Co., Building Management.

[1]The Paul system is essentially a one pipe steam system where instead of individual radiator vent valves which vent the air into the rooms, the vent valves discharge the air into a network of air removal piping. The vent valves are thermostatic and pass air into the collecting pipe system but are closed automatically when the temperature of the steam reaches them. The water of condensation flows back into the feed pipe through the inlet steam valve. The air vent piping is collected into basement mains and carried over to the ejector system, where, usually by steam actuated ejectors, the air is forced out of the system and a slight vacuum maintained on the vent piping.



ALDIS & CO., AGTS., MONADNOCK Building

Record of Hourly Temperatures during month of January 1936

Date	M	1	2	3	4	5	6	7	8	9	10	11	N	1	2	3	4	5	6	7	8	9	10	11	Av
1		72	72	71	71	70	70	69	69	68	68	70	71	72	73	74	76	75	75	74	72	71	71	69	67
2		67	67	66	65	65	64	63	63	69	74	76	76	76	76	74	72	73	76	75	72	69	67	66	66	69
3		65	63	63	62	61	61	61	61	63	67	69	70	71	72	72	72	74	72	72	72	72	70	69	68	68
4		67	67	66	66	65	65	66	66	66	67	69	70	71	72	72	72	73	75	76	76	74	71	70	68	
5		67	67	67	66	66	65	65	65	67	70	72	72	72	73	73	72	73	73	74	69	69	66	66	64	64
6		64	63	63	[illegible]	67		66	66	63	67	69		73	73	73	[illegible]	73		74	74	70		67		
28		71	71	69	69	69	[illegible]	68	67	67	70	72		73	74	74	74	74		69	69	66	66	66	67	
29		67	65	59	58	57	59	61	61	62	63	66	67	68	69	70	71	72	72	72	72	72	72	72	72	
30		71	71	70	70	69	70	71	72	72	72	72	71	72	73	73	73	73	73	73	73	73	73	72	72	71
31		68	67	65	64	63	62	62	67	69	71	72	72	72	72	72	73	73	74	74	68	65	66	63	62	63
		12	1	2	3	4	5	6	7	8	9	10	11	N	1	2	3	4	5	6	7	8	9	10	11	
Ave.		65.9	65.6	65.1	64.5	64.0	63.7	63.5	64.3	65.6	68.4	70.3	71.3	72.0	72.5	72.7	72.9	73.0	72.8	72.5	70.4	69.1	68.1	67.3	66.5	

Total Average 68.32

Fig. 1—Chart showing manner in which hourly temperatures taken from the three day chart of Fig. 7 are entered on a form and averaged vertically. From the hourly averages shown in the bottom row of figures, temperature curves similar to those in Fig. 2 are constructed

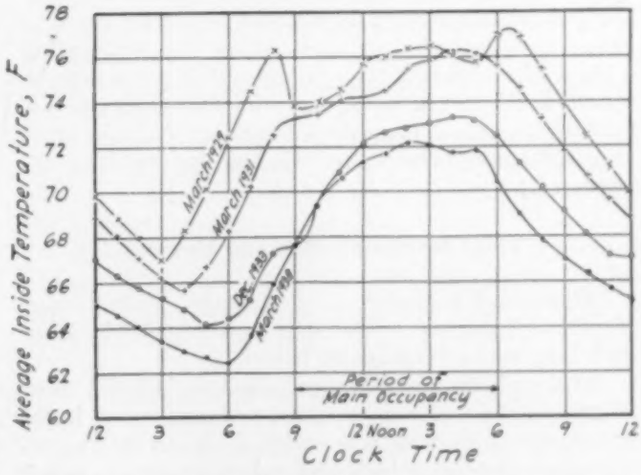


Fig. 2—Curves showing average prevailing space temperatures. Note decrease in temperature level

Two Avenues of Heating Economy

After a season or two of experience, two avenues of heating economy were evident. One was to increase the economy of steam generation by installing mechanical stokers. With this program some curtailment of labor costs was also indicated. The other economy lay in the direction of better control of steam sent upstairs for heating; this was the more difficult of solution.

The improvement in steam generating practice was accomplished by the installation of two underfeed, forced draft stokers in 1930 and a third one in 1931, the fourth boiler being left hand fired and used only in weather actually below zero or for standby purposes at other times.

Determining Building Temperatures

In order to determine temperature conditions upstairs by which to govern heating operations, a simple expedient was hit upon. We obtained two portable recording thermometers with a range from 50 to 90 deg and equipped for 72 hr charts. These thermometers are passed around over the building and each one is moved every night to the next floor above or below and to the next office, so that several times throughout the heating season each instrument makes a fairly complete traverse of the building.

To determine average prevailing building temperatures, the charts for a given month are assembled and the hourly temperatures taken off. These are entered crosswise on a sheet and the temperatures averaged vertically (Fig. 1). There is little question but that the averages of the hourly temperatures truly represent the average conditions in the building, and these are plotted for comparison with previous conditions or with other buildings.

The placement and shape of the first curves, Fig. 2, indicated what might be done along the lines of heating economy. For instance, the bumps at 8 a. m. and 5 p. m. on the curve for March, 1929, definitely indicated that the occupants upon entering the offices in the morning found them too hot and were opening the windows to cool off the premises. Again, when they left around 5 p. m., they were closing the windows and the temperatures rose thereafter. It appeared immediately that the general temperature level could be carried lower in order to obviate these consequences of overheating. (Curves for several months in succeeding years are also shown and it can be noted that with the conservation of heating steam and the general lowering of temperatures these evidences of excessive window opening have disappeared.)

Heat Switching Machine Devised

We decided to design an electrically switched "heat dispensing" machine. The salient points of this device as it was worked out are as follows:

An electrically operated stop valve was installed ahead of each of the four zone pressure reducing valves in the basement. A machine was designed, driven by an electric motor through a high ratio speed reducer, to switch the valves on and off (open and closed) in rotation

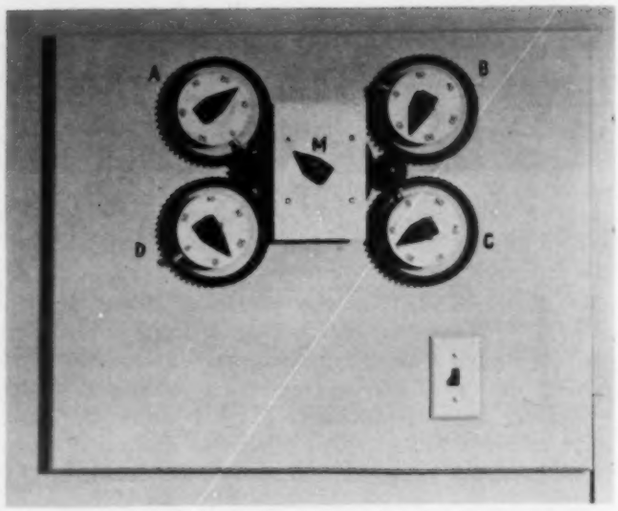


Fig. 3—Front view of heat switching machine. The turning on of the four sections A, B, C, and D, is indicated by the center pointer. The turning off of the four sections, and the timing of the steam shot, are accomplished on the four smaller dials, each with its pointer and thumb screw

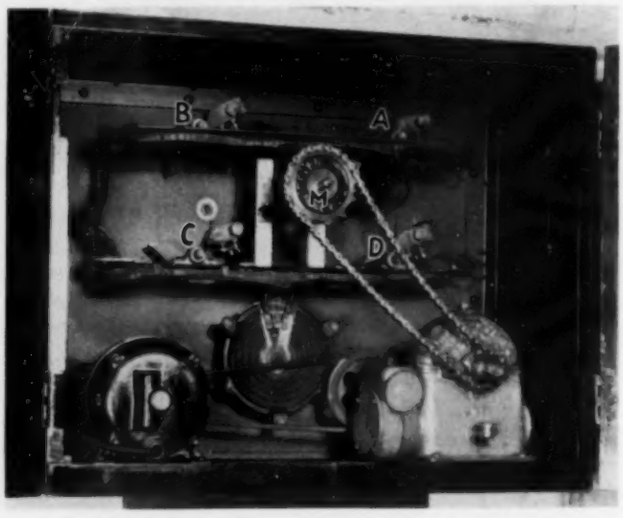


Fig. 4—Rear view of switching machine. The mercury switches may be seen mounted on fiber pivots; also the fiber knockers attached to the rotating shafts

from one end of the building to the other, and to repeat this continuously. The length of time any one valve is open can be adjusted independently of each of the others. Provision is made in the design of the switching mechanism to vary the cycle of operation over quite a wide range, for the present operating cycle of 22 minutes was determined only after experimentation.

A description of the construction and operation of the switching machine is simplified by reference to the two accompanying photographs. Let us start with the main shaft, designated by "M" in each photograph. From an 1800 rpm motor this shaft is driven through a pulley and belt reduction and a 3600 to 1 speed reducer so that it revolves once in 22 minutes.

Mounted on shaft "M" are four fiber knockers set at 90 deg intervals which operate in rotation four mercury switches mounted nearby on fiber pivots. These are the "turning on" switches and there is one for each of the

four electric zone valves. It will be perceived that the order and time at which the valves are turned on is a fixed relation and that no two sections can be turned on simultaneously, although if the machine be set for long intervals there may be more than one section on at a time.

From the main shaft "M," auxiliary shafts and dials "A," "B," "C," and "D" are driven through spur gears. A mercury "turning off" switch mounted adjacent to each of the four secondary driven shafts turns off its own valve. Herein lies the mode of establishing the length of the shot of steam admitted to the heating system by the valve.

Referring to Fig. 3, each zone gear carries a dial affixed to it, the dial being calibrated from zero to 60 by 10 minute intervals, indicating the number of minutes "on" per hour. This gear is mounted on a shaft to which a fiber pointer is keyed and the shaft is free to turn in the bore of the gear but may be held in any predetermined position by a thumb screw through the hub of the gear. Also keyed to this secondary shaft is a fiber knocker which tips up the mercury "turning off" switch. It will be seen from the foregoing that the gear and numbered dial turn at the same speed as the central shaft and bear a fixed relation to it, but that the point at which the fiber knocker operates the "turning off" switch will depend upon the setting of the pointer with the thumb screw. This relation is such that when the pointer is set at 20, for example, the corresponding valve will be open 20 minutes out of each hour, or 33⅓ per cent of the time. It follows that due to the cycle being timed for 22 minutes, this adjustment will alternately have the valve open for approximately 7 minutes and then closed for about 15 minutes.

In very mild weather the pointers are set to keep the valve open 5 minutes out of the hour, which means that the steam will be on a minute and a half and then off 20½ minutes. In zero weather the dials are set for 35 minutes out of the hour, and out of each 22 minutes the steam will be on 13 minutes and off 9 minutes.

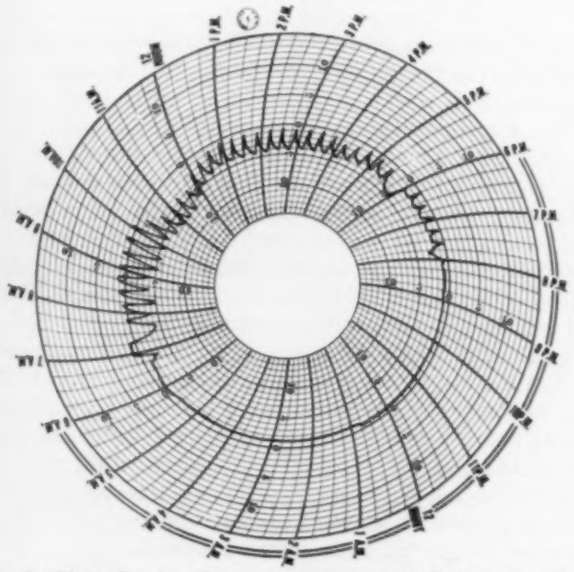


Fig. 5—Chart showing the pressure-vacuum conditions prevailing in a typical radiator during a day when the outdoor temperature averaged 37 deg. Chart reads in lb per sq in gage pressure, with the vacuum range toward the center and the pressure range toward the outer edge

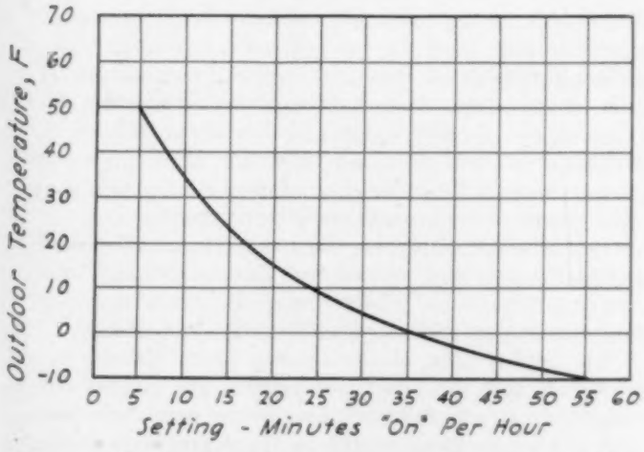


Fig. 6—Chart illustrating the approximate settings of the machine dials for different outdoor temperatures

Operation of the Switching Mechanism

The heat switching system was installed in the summer of 1931 in the office of the superintendent of the building, who was assigned to manipulate it. It was believed the superintendent was in a better position to know the temperature requirements and the existing temperature range than would the engineer from his more remote station in the basement.

The efficacy of the machine and its mode of use depend upon the judgment of the superintendent. He has interested himself in its operation and has accomplished excellent economy with it. Due to its flexibility we believe this has been done with a very minimum of difficulties with the occupants of the building.

A new turning-on schedule was devised and the engineers required to turn the steam on by manual operation of the corresponding valves, in the early morning hours according to the outdoor temperature as revealed by a remote thermometer which is read in the boiler room. This turning-on schedule is designed to bring the building to an average temperature of 68 deg at 9 a. m. At 9 a. m. the building superintendent steps to the control board in his office and places the four electric valves in operation after having started the switching machine and set the four dials for the amount of steam service necessary (in his opinion) to maintain the building at 70 to 72 deg with the prevailing weather conditions. With changes in weather he may readjust the dials during the day.

At the end of the day, the superintendent switches off the different sections at a time such that the temperature of the space will fall off about as rapidly as is feasible without encountering complaints from the occupants, the theory being that the radiators retain heat for half an hour or so and that it is not necessary to have steam service to the radiators up to the time of departure of the occupants.

Conditions in the Heating System

Soon after putting into effect this limitation in the steam sent upstairs for heating, "low spots" began to appear in the building; that is, certain premises were

always the first ones to complain of inadequate heat. These deficiencies in radiation or from other causes were corrected in the manner appropriate to each and after 15 or 20 such low spots were corrected, mostly by installing additional radiation or by weatherstripping windows, the building seemed to be uniformly radiated and the steam control began to go smoothly.

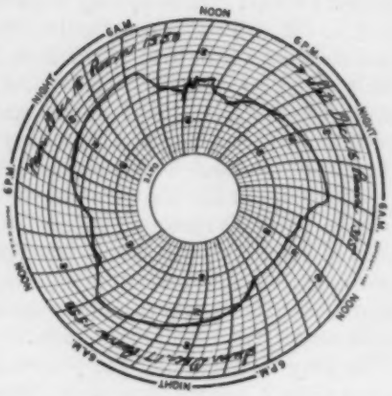


Fig. 7—Typical three day temperature chart taken during December, 1938. From these charts the monthly temperature curves, Fig. 2, are composed by the method indicated in Fig. 1

It is probably well at this point to describe the conditions in the cast iron radiators under this mode of operation. It is found that in normal heating weather the radiators are under vacuum at all times during the machine switching operation, the amount of vacuum varying over the complete 22 minute cycle. Conditions for a typical day are shown in Fig. 5. Recording thermometer data are also available as to the average temperature of the radiator during this process. It was found first that in severe weather the radiators are uniformly heated from end to end and that the average temperature of the surface of the radiator varies somewhat in proportion to the length of time the steam shot is left on during each cycle—the temperature being greatest for the longer steam shots and least for the short.

The radiator temperature variation during the 22 minute cycle is only about 10 deg. In mild weather when the duration of the steam shot is a very small portion of the 22 minute cycle, the radiators do not heat all the way across and thereby additional control over and beyond that due to the temperature of the radiator surface itself is accomplished. Fig. 6 shows the average setting of the machine dials for different conditions of weather. It should be realized that the steam consumption for the building is not strictly proportional to the setting of the machine dials, for the rate of condensation

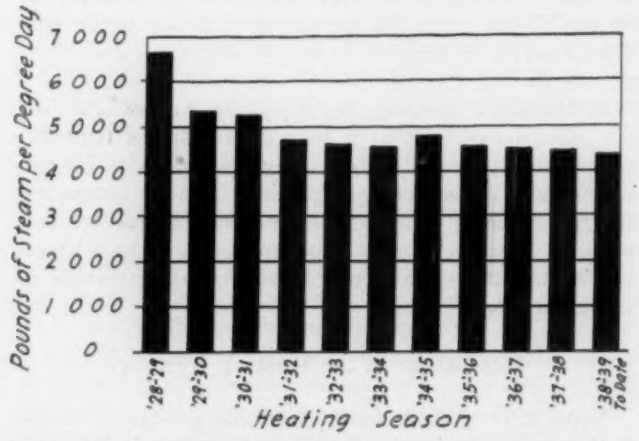


Fig. 8—Graph showing the decrease in steam per degree-day with the application of the machine switching program and other changes in heating practice

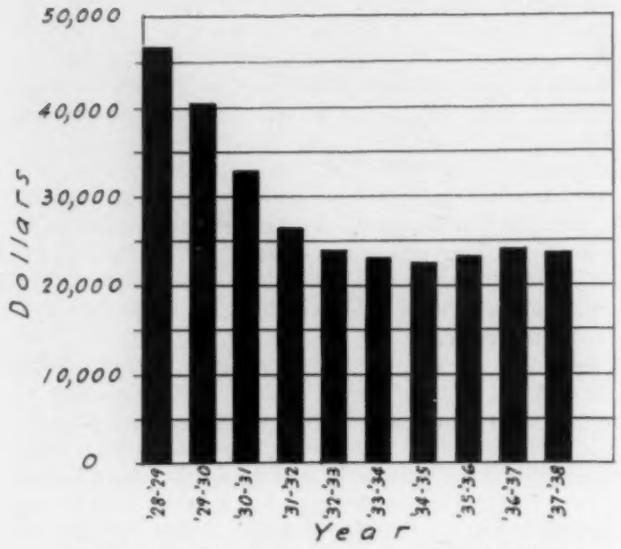


Fig. 9—Chart showing decrease in cost of heating

is several times as great during the first few minutes of a shot as it is during the later portions of the shot.

In Fig. 7 is shown a typical 72 hr chart taken from one of the recording thermometers passed around over the building. In addition to the purpose outlined above, this instrument is occasionally placed in premises where difficulties seem to be occurring and valuable information is obtained from its records. Our experience indicates that one of these thermometers should be provided for each 100,000 to 150,000 sq ft of rentable area. They are useful and worthwhile, of course, only to the extent that the data from them are actually analyzed and used. One of the easiest ways to verify the conditions of heating economy (or lack of it) in a building is to obtain one of these little instruments and use it in the manner indicated above. The temperature curves made with it will tell the intelligent engineer at a glance whether his heating practices offer room for improvement or whether they are already up to a proper standard.

Trend of Heating Steam Consumption

The trend of steam consumption in the building is shown in Fig. 8 and the trend of heating costs in Fig. 9. These indicate the combined results of better generating economy and more careful utilization upstairs. They reflect a number of different changes, such as conversion of the boilers from hand to stoker firing; the cancellation of a contract under which about half of the heating steam was purchased from a neighboring building; revision in the labor set-up for producing the steam (this change being made possible by mechanical stokers); revised schedule of turning the steam on and off according to the weather; intermittent shots of heating steam during the day; and closer control of steam and space temperatures at night and on Sundays and holidays.

The performance of the heating plant, the machine switching and the system of control are judged continually by two standards. One is the steam consumption for the building related to the degree-days during the period, and the second is the average temperatures maintained in the space heated.

Rectifiers Protect Piping from Electrolytic Corrosion

By I. R. Smith*

On account of the growing interest of engineers and maintenance supervisors in the use of cathodic protection against corrosion in water tanks and similar structures, we believe this review of this electrical means of corrosion prevention as applied to pipe lines, etc., will be of interest to our readers

CORROSION of pipe lines, cable sheaths, and other underground structures has been a major source of concern to operating engineers for many years. Not only in urban areas where the problem was largely related to the d-c street railway systems, but also in other districts far removed from any source of stray d-c currents, failures of pipes and cables due to electrolytic action have been of vital importance. Not only do such failures cause interruption to important services, but the effort required to keep down the rate of failure has been a heavy financial drain. Intensive study of the problem by electrolysis engineers has (during the past ten or twelve years) resulted in the development of protective measures that give promise of bringing this universal trouble-maker under control.

Currents Cause Pitting

Whenever a direct current departs from a pipe or cable sheath into the surrounding soil, metal usually is carried with it. The loss of metal results in pitting, the depth of which will increase with time until finally there is a hole in the pipe. Wherever direct current enters a pipe from the soil, pitting normally does not occur. The point of current departure is called the anode; where the current enters is called the cathode.

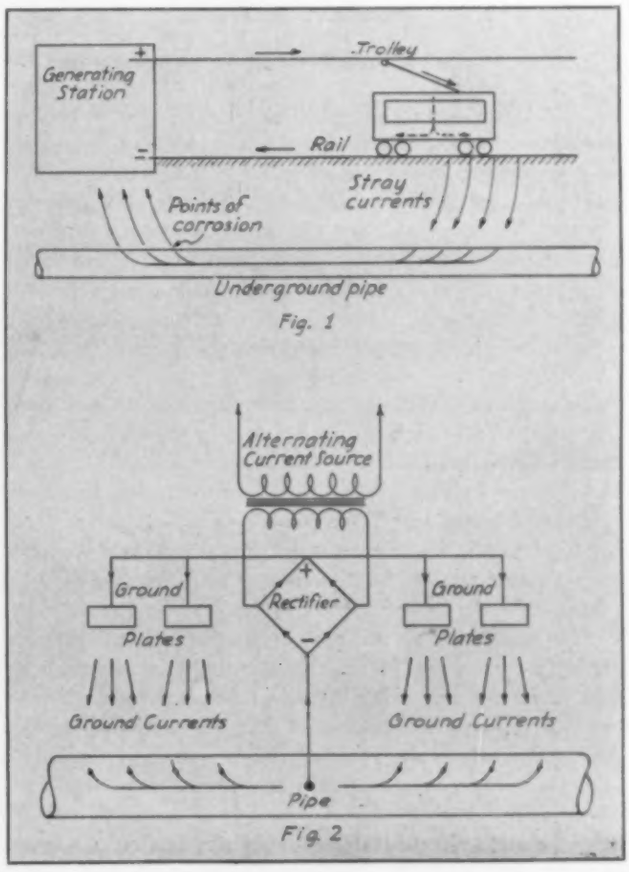
The currents in the underground structure may be either of two types, stray currents or electrolytic currents. The effect of the two is the same, though their sources are quite different.

Stray Currents—Stray currents are currents which have wandered from their proper location, as the name implies. Most commonly this would be the rail system of a d-c railway. As shown in simple form in Fig. 1, direct current moves out along the trolley line from the generating station to points where cars may be located. The current then travels from the trolley down to the rail, through the lights, motors, etc., and returns along the rail to the power house. The rail, however, is not an insulated conductor. It is connected substantially over its entire length to another conductor, the earth. True, the specific resistance of the rail metal is far below that of the soil. On the other hand, the cross section of the soil that is available as a conductor is far greater than the rail. Thus the soil becomes in effect another conductor for the return current, in parallel with the rail. Consequently not all the current can stay on the rail on its way back to the power house—some of it must leave the rail and travel through the earth. This, then, is stray current.

Consider the underground pipe in Fig. 1 near the rail and more or less parallel to it. Obviously, due to the low resistance of the pipe, some of this stray current in the soil will prefer to travel on the pipe, which it does. Eventually the current reaches that part of the pipe which is nearest to the generating station, where it must return—so it leaves the pipe again, travelling back through the soil to the negative bus. At the point where it leaves the pipe, corrosion occurs.

Electrolytic Currents—Street railways and stray currents are not necessary to cause corrosion, as operating engineers realize when they inspect their boiler tubes. Pitting can also occur from electrolytic causes. Electrolytic currents occur because of the fact that the soil in which the pipe rests contains moisture and various salts,

Fig. 1 (above)—Stray current electrolysis, showing path of stray current returning from the rail through the earth and an underground pipe to the negative bus. . . Fig. 2 (below)—Cathodic protection system. Cathodic protection is obtained by making the pipe negative to the earth with an external source of d-c



*Control Engineer, Westinghouse Electric & Mfg. Co.

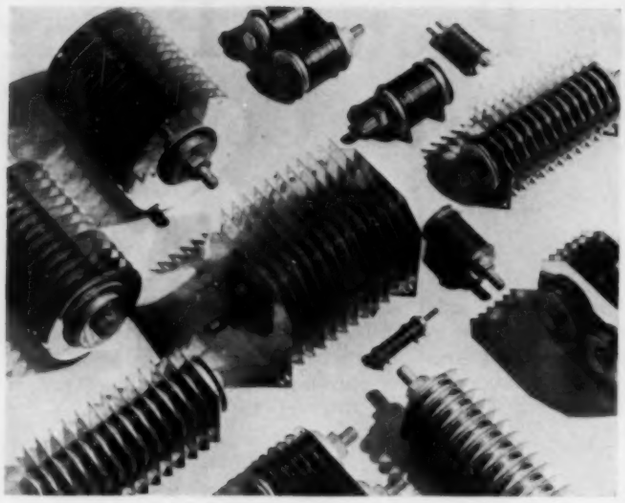


Fig. 3—Typical copper-oxide rectifier units of the naturally ventilated type

and hence is an electrolyte. Small voltaic cells then may set themselves up along the pipe, due to variations in contact potential at various points which may be due to irregularities in the surface or the composition of the pipe itself. These tiny cells send current out into the soil electrolyte at some point, which may have a higher contact potential than some other nearby point, which consequently becomes an anode. The current returns at the point of lower potential, which is the cathode, the circuit of course being completed by the pipe itself. At the anodic points, metal is carried off and pitting results.

Protective Measures

There are several methods of combatting these two types of corrosion.

Insulation—For example, it is obvious that in the case of stray current, trouble would be avoided if the return d-c conductor were completely insulated from earth. The expense and difficulty of accomplishing this has prevented its adoption. By the same reasoning, however, if the pipe itself could be insulated, no current would climb on and no electrolysis could occur. Many elaborate methods for doing this have been devised, involving the use of wrapped coatings impregnated with hot tar, etc. These, when properly applied, reduce greatly the amount of electrolysis. If, however, there are pin-holes, cracks, and scratches, contact is established by the soil electrolyte with the bare metal, and conditions favorable for electrolysis are set up. The result is that such lines may have to be dug up and re-coated periodically.

Drainage—A different approach to the problem does not attempt to prevent the current reaching the pipe but tries to control the manner of its leaving by providing a low resistance return path from the pipe to the negative bus, which path (if the resistance is low enough) the currents will elect to use in preference to the soil. If the return current can be made to travel by way of this bond, then electrolysis will be eliminated. This is known as "drainage," and when properly carried out is very effective.

It should be emphasized that the application of a drainage system of any type is not the simple matter it may appear from this necessarily condensed description, but is an extremely complicated and involved problem, the solution of which may require years of study. In fact, it may be said to be insoluble, in the sense that changing conditions generally require changes in the methods or arrangements of the drainage systems used. Unfortunately, experience gained in one location cannot be applied forthwith to another, but each has to be studied by itself as a new problem.

Cathodic Protection

In the past ten or twelve years the use of electric drainage has been expanded to take care of electrolysis caused by electrolytic action; that is, where no stray current exists for use in protection. As has already been pointed out, corrosion practically always occurs where current leaves the pipe—in other words, where the pipe is anodic. It seldom occurs where current enters the pipe—or where the pipe is cathodic. Hence, if the entire pipe surface, wherever it is in contact with the electrolyte, could be made cathodic, evidently corrosion would be eliminated. Making the pipe cathodic (or negative) to the electrolyte then requires an external source of electrical potential, which can be applied between the pipe and the earth, capable of forcing the pipe below the earth potential and keeping it there. This system, known as cathodic protection, is not new in conception, having been tried out as far back as 1912, but for many years it was viewed with great skepticism and made little progress. Recently, as the result of the work of certain pioneering electrolysis engineers, it has been definitely established that so-called cathodic protection not only will check corrosion but will usually save money in the process.

A cathodic protection installation is shown diagrammatically in Fig. 2. A source of direct current—which might be a battery or d-c generator, but is shown here as a rectifier—has its negative terminal tied solidly to the pipe, while its positive terminal is connected to well made grounds at suitable distances from the pipe. Current will flow from the rectifier to the ground plates, then through the earth to the pipe, and back to the rectifier again. Hence the pipe is cathodic to the soil electrolyte, and if the installation has been properly engineered will not corrode. Such installations are spotted along the pipe as required.

The methods of determining the amount of d-c voltage and current needed in order properly to correct conditions, and the frequency or spacing of the individual locations of d-c power sources involve a large amount of work by men experienced in electrolysis work. It is not our purpose here to go further into that phase of the matter, except to say that each case has to be studied and solved by itself, due to the variations of the controlling factors, such as soil resistivity, type and size of pipe, condition of pipe covering, pipe maintenance, economics, etc. Papers and articles are available which go deeply into all phases of this work.

Electrolysis installations require continuous and quiet operation; no radio interference; minimum of maintenance; efficient operation; low first cost; long life;

minimum size and weight; outdoor installation, pole mounting, etc.; ease of repair and adjustment; minimum number of moving parts; and rugged equipment. Where a-c power is available, the copper-oxide rectifier has been found to meet these requirements.

Some Copper-Oxide Rectifier Characteristics

Of the requirements, perhaps the most important is freedom from maintenance and replacements. In a properly made application of a copper-oxide rectifier, which has no moving parts, and which does not wear out, there should be no maintenance required, barring accidents. When it is realized that these installations are likely to be made in locations far from any service shop and perhaps inaccessible, the importance of this factor can be appreciated.

Next in importance might be placed operating cost. The efficiency of the copper-oxide rectifier does not change with voltage output, but is the same at 10, 100, or 1000 volts. This is because the rectifier in effect is a resistance type of device, and since the number of discs in series will vary in proportion to the output voltage rating, so also will the losses vary. With losses and output then varying in proportion to voltage rating, efficiency must of course remain unchanged. The copper-oxide rectifier then can operate at the low voltages ordinarily required for electrolysis work at very good efficiency. A set of performance curves for a typical electrolysis unit is given in Fig. 4. Here it may be seen that efficiency is close to 60 per cent when new, at full load, and remains substantially constant over a wide range of loading.

Another factor in performance is power factor. Power factor is important because of its effect on the demand on the power line. In such a rectifier, power factor is uniformly high, approximately 95 per cent or better. Voltage regulation (that is, the change in output voltage with load) will run around 25 per cent. This is of no importance in the usual application, where the load is fairly constant; in special cases, where the load varies, and it may be desired to keep the voltage or the current constant, control schemes are available which will accomplish these results.

Adjustment of output has to be made (only infrequently) in the usual electrolysis installation, as local conditions may change requiring more or less correction from the d-c source. The rectifier may be built with any degree of adjustment required. Usually, several taps are provided on the transformer secondary, which permit changing the a-c voltage applied to the rectifier unit, and consequently the d-c output. Finer control can be obtained by rheostats, adjustable reactors, or variable transformers of one type or another.

The construction of a copper-oxide rectifier is illustrated in Figs. 5 and 6. For indoor use, where no weather protection is needed, the rectifier may be mounted in a standard ventilated cabinet, Fig. 5. Outdoor service calls for a type of box with overhanging roof such as shown in Fig. 6. Rain and snow are kept out, but ventilating air may circulate freely through the box. This illustration shows the rectifier units, the disconnect snap switch, the knob of the dial switch used for selecting transformer taps, output ammeter, and a-c and d-c fused terminals.

Capacity requirements in this type of service may cover a wide range. Sizes have been built from 36 watts (6 volts, 6 amperes) up to about 2 kw (55 volts, 35 amperes). The average size may be about 500 watts. Fig. 7 illustrates a 6 volt, 200 ampere unit for indoor mounting. In this case, the size and cost of the rectifier were materially reduced by adding a ventilating fan. This results in a greater increase in output per pound of rectifier material, for capacities of this size or larger.

Fig. 4—Performance curves for a typical single phase unfiltered copper-oxide rectifier as built for cathodic protection. Power factor, not shown, will exceed 95 per cent

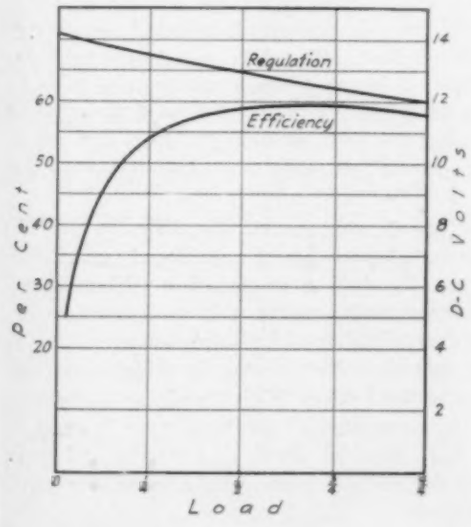
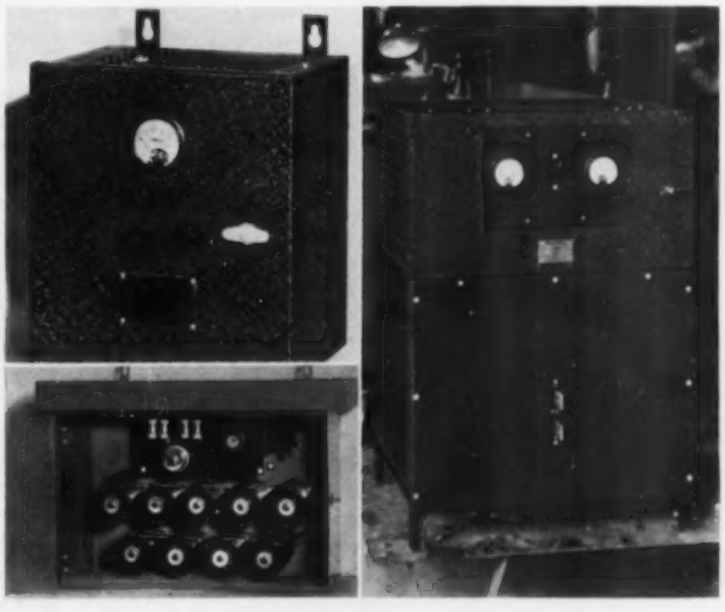


Fig. 5 (upper left)—Copper-oxide rectifier, indoor mounting. Indoor installations are made in ventilated housings. . . Fig. 6 (lower left)—Outdoor mounting. Outdoor installations require protection from weather without interfering with the ventilation of the outfit. . . Fig. 7 (right)—Forced ventilation unit. A large capacity indoor installation, rated at 200 amperes, 6 volts d-c output, built with forced draft in order to save space and cost



Protection for Other Types of Structures

Considerable time and money is spent to protect the interiors of water tanks against the effects of electrolytic action, such protection requiring scraping and painting at regular intervals. Installations are now being made of cathodic protection systems in these tanks, involving again the use of positive electrodes and small sources of d-c power. One such installation on a 200,000 gal water tank has been in successful operation for some time. Another, on a 50,000 gal tank at Mansfield, Ohio, is in satisfactory operation, although the installation is as yet too new to permit making definite statements as to the savings realized. Still other installations have been reported.

This development in the cathodic protection field will be carefully watched as the problem of electrolysis in standpipes and many other similar structures is almost universal. Although it can hardly be said as yet what the economic value of protection may be in these newer fields of application, the likelihood of success in many cases seems very promising, so that a new technique of protection for such structures may well be in the making.

It is important to point out again (in conclusion) that electrolysis problems are not simple in solution, but often are extremely complex, requiring long study and many efforts at protection before the right answer is found. In underground work, often several utilities are involved and co-operation is necessary to avoid protection of one property at the expense of another. The same situation will no doubt be found in the protection of equipment other than pipes and cables. Hence, it is important that the study of the problem and its solution be entrusted to skilled electrolysis engineers if success is to be secured.

Trouble With a Flue from a Heater

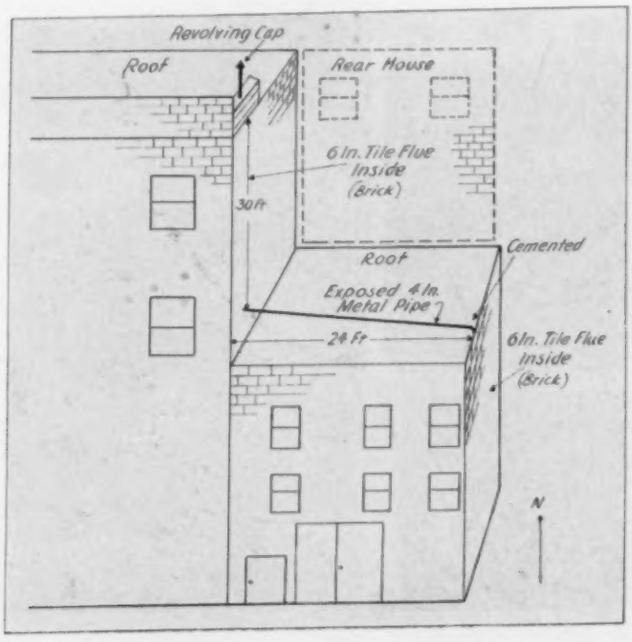
[Samuel R. Lewis* answers a reader's question]

A READER submits the accompanying sketch of a flue which gives trouble because of a back draft. As indicated, a small kerosene heater vents into a 6 in. vertical tile flue which rises through the first, second and third stories of the building in which the heater is placed, then crosses about 24 ft horizontally above the roof to a second 6 in. tile flue which rises 30 ft to a revolving cap.

The horizontal duct above the roof is of metal and is 4 in. in diameter. It is covered with paper and canvas and has a small pitch upward in the direction of travel of the gases. The tile flue into which this duct discharges is in a chimney built into the outside wall and it is evident that the small amount of heat remaining in the discharge gases from an efficient kerosene heater easily can be dissipated, through so long a duct, exposed as it is to an unusually large heat-losing surface.

*Consulting Engineer. Member of Board of Consulting and Contributing Editors.

Sketch of the flue which gives trouble



The complaint does not indicate what eddy currents from winds in various directions also may affect the outlet from the top of the chimney, but the presence of the revolving cap suggests that this was installed in the hope that it would alleviate such a situation.

I have seen a straight tile chimney more than 500 ft high in the outside wall of a building which was so cold and which received so much air by leakage that it always had a down draft unless a very hot fire was maintained at its base.

It is not surprising that the plant described causes trouble, and the man who prescribes a remedy without more information than is given, is indeed foolhardy. Perhaps a warmer chimney can be found somewhere in the vicinity. I would make sure that the exposed side of the 30 ft chimney is thoroughly pointed up so that infiltration is minimized. The 4 in. metal pipe probably should have been 6 in., and paper and canvas form by no means an adequate insulation for such a pipe. I would have called for at least an inch of air cell covering with a waterproof composition roofing jacket on this pipe.

Perhaps the safest way out of the difficulty will be to install an induced draft fan of centrifugal type in the connection from the heater to the first chimney, arranged to operate continuously, with an automatic device which in case of failure of electric energy going to the fan motor will close by a spring or weight the supply of kerosene to the heater. This should give adequate protection to the occupants of the building. It must be remembered that Admiral Byrd was nearly killed by slow poisoning due to failure adequately to remove products of combustion.

Performance of Coils for Dehumidifying Air

By William Goodman*

THE appendices for this series of articles on performance of coils for dehumidifying air are continued this month, and will be concluded in the April HPAC. In this series, the author has developed new and simple formulas for computing the final dry and wet bulb temperatures of the air leaving a coil. Particularly noteworthy is the fact that the final wet bulb depression of the air has been shown to depend upon the initial wet bulb depression of the air for both direct expansion and counterflow coils. This makes computation of the final dry bulb temperature the work of a moment.—THE EDITOR.

Appendix 3

Methods of Eliminating h_s and t_s from Equations 1 and 2 of Appendix 2

The computation of the transfer of heat from air to a cold wetted surface is based on the following two fundamental equations, the derivations of which are given in Appendices 1 and 2:

$$dH_w = \frac{f_s}{c}(h - h_s)\,dA_w \quad \ldots\ldots\ldots\ldots\ldots\ldots [1]$$

$$dH_w = \frac{f_R}{B}(t_s - t_R)\,dA_w \quad \ldots\ldots\ldots\ldots\ldots\ldots [2]$$

As shown in the text, the value of t_s, the surface temperature of the coil, is not constant—it varies throughout the coil. Therefore, in order to integrate [1] and [2], the variables t_s and h_s must be eliminated by a simultaneous solution of the two equations. This can be accomplished only if h_s can be expressed in terms of t_s. Although the enthalpy of the saturated air in the surface film depends only upon the value of t_s, no rational equation exists that connects these two terms. Hence, empirical methods must be used for eliminating h_s and t_s from Equations 1 and 2. This has been the fundamental difficulty facing all investigators of the subject, regardless of how they have attacked the problem. Various ways of overcoming this obstacle have been proposed.

In one commonly used method, the variation in surface temperature is neglected. By assuming that the surface temperature is constant regardless of the area of the surface, Equations 1 and 2 can be integrated and rather simple equations obtained. However, inasmuch as the average surface temperature appears in the final equations, it must first be found each time these equations are used to solve a particular numerical problem. Instead of eliminating t_s and h_s in the original equations, they can be eliminated only for a particular numerical problem. Furthermore, such equations by their very nature are true only as long as the range of surface temperatures is so small that the extreme values do not differ much from the average.

In an effort to take the varying surface temperature into account, the author used (in his ASRE paper[1]) a second degree empirical equation of the following form for relating the enthalpy of saturated air to its temperature.

$$h = m + nt + pt^2 \quad \ldots\ldots\ldots\ldots\ldots\ldots [3]$$

(In this formula, m, n, and p are empirical constants.)

By a proper choice of constants, this equation can be made to represent the relation between h_s and t_s quite accurately over a wide range of surface temperatures. However, the use of

Symbols

a = a numerical coefficient. See Table 1.
A_D = external area of dry surface, sq ft.
A_T = total external area of coil surface, sq ft.
A_W = external area of wetted surface, sq ft.
B = ratio of external to internal surface area of coil.
c = humid specific heat of air (average $c = 0.243$).
D = wet bulb depression of the air, deg Fahr.
$D'' = t''_1 - t_R$, or $t''_1 - t_{R2}$
$D_R = t_R - t_R$, or $t_R - t_{R2}$
e = base of natural logarithms.
f_s = coefficient of heat transfer through air film, Btu per hr per sq ft per degree of temperature difference.
f_R = coefficient of heat transfer through refrigerant film, Btu per hr per sq ft per degree of temperature difference.
G = weight of air, lb per hr.
G' = weight of refrigerant, lb per hr.
h = enthalpy (total heat) of humid air, Btu per lb of dry air.
h_R = enthalpy (total heat) of saturated air at a temperature equal to the refrigerant temperature, Btu per lb of dry air.
h_s = enthalpy (total heat) of saturated air at a temperature equal to the surface temperature, Btu per lb of dry air.
H_D = total heat transferred through dry surface of coil, Btu per hr.
H_s = sensible heat lost by the air flowing past the wetted surface, Btu per hr.
H_W = total heat lost by the air flowing past the wetted surface, Btu per hr.
M = a numerical factor. See Equations 7, 11 and 24.
$R = \frac{Bf_s}{f_R}$
t = dry bulb temperature, deg Fahr.
t' = wet bulb temperature, deg Fahr.
t'' = dew point temperature, deg Fahr.
t_D = boundary dry bulb temperature, deg Fahr.
t_R = refrigerant temperature, deg Fahr.
t_s = surface temperature of coil, deg Fahr.
U_W = over-all coefficient of heat transfer through wetted surface of coil, Btu per hr per sq ft per Btu of enthalpy difference.
θ = angle in Fig. 4.

The subscript "1" refers to the initial condition of the air or refrigerant entering the coil. The subscript "2" refers to the final condition of the air or refrigerant leaving the coil.

*The Trane Co. Member of Board of Consulting and Contributing Editors.

Part 5. Part 1 was published in November, 1938, pp. 697-701 and 707; Part 2 in December, 1938, pp. 777-781; Part 3 in January, 1939, pp. 13-19; and Part 4 in February, 1939, pp. 83-86.

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such a second degree equation leads to equations which, though they yield accurate results, are not as simple as the analogous equations used in computing heat transfer across dry surface. Furthermore, a real disadvantage of the second degree equation is that an equation for the final dry bulb temperature of the air cannot be obtained by its use.

In an effort to avoid the difficulties involved in using a second degree equation, and at the same time to take into account the variation in surface temperature, the following relationship, which is discussed fully in Appendix 4, is used in this article:

$$\frac{h_s - h_R}{t_s - t_R} = a \quad \ldots\ldots [4]$$

The value of a depends only upon the refrigerant temperature, and the method of computing it is discussed in Appendix 4. The use of Equation 4, with different values of a, is equivalent to using a whole series of first degree (straight line) equations for relating h_s and t_s; a different equation being used for each refrigerant temperature.

Although Equation 4 does not accurately represent the relationship over as large a range of surface temperatures as does a second degree equation like [3], it is nevertheless fairly satisfactory for the range of surface temperatures ordinarily encountered.

The use of Equation 4 for eliminating h_s and t_s between Equations 1 and 2 results in a simple equation of familiar form for the heat transferred through a wetted surface. Furthermore, it also leads to a simple equation for the final dry bulb temperature of the air.

To summarize briefly, up to the present time three empirical methods have been used for eliminating h_s and t_s in Equations 1 and 2:

1. The assumption that t_s, and hence h_s, is constant.
2. The assumption that the relation between h_s and t_s can be represented by a second degree equation.
3. The assumption that the relation between h_s and t_s can be represented by a series of first degree equations, each depending upon the refrigerant temperature.

The third method is the one on which the equations in this article are based. As shown in Appendix 16, the results obtained agree with the results of experiments on coils in which the refrigerant temperature is constant, and on counterflow coils in which the temperature of the refrigerant varies.

Appendix 4

Method of Computing Values of a in Table 1

The values of a in Table 1 were computed by means of the psychrometric tables in the reference of Footnote 3. These values were computed by means of the following formula:

$$\frac{h_s - h_R}{t_s - t_R} = a \quad \ldots\ldots [1]$$

Numerical values were substituted for h_R and t_R for each degree of temperature from 20 to 69 deg. Numerical values were then substituted for h_s and t_s for each degree of temperature for a range of 20 deg above the refrigerant temperature as long as the refrigerant temperature was below 50 deg. For refrigerant temperatures above 50 deg, no values of surface temperature higher than 70 deg were used. After each value of a was thus determined, the average value of a was found for each refrigerant temperature. Table A shows how the average values of a were computed for two of the refrigerant temperatures. Average values of a were computed in a similar manner for each of the refrigerant temperatures listed in Table 1. These average values of a were then plotted on a large scale sheet of cross section paper and a curve drawn. The values of a listed in Table 1 were read from this curve.

A range of surface temperatures of about 20 deg above the refrigerant temperature was selected because this is about as high a surface temperature as will be ordinarily obtained on a wetted surface. For the higher refrigerant temperatures, the surface temperature was stopped at 70 deg because higher surface temperatures than this are not often encountered on wetted surface in ordinary work.

Table A — Illustrating How Average Values of a of Table 1 Were Computed

t_s	t_R 45	t_R 55
45	.....	.....
46	0.510	.....
47	.515	.....
48	.517	.....
49	.523	.....
50	0.530	.....
51	.535	.....
52	.540	.....
53	.545	.....
54	.550	.....
55	0.556	.....
56	.562	0.620
57	.568	.625
58	.574	.633
59	.580	.640
60	0.586	0.646
61	.592	.653
62	.599	.661
63	.606	.668
64	.612	.674
65	0.620	0.683
66	.....	.690
67	.....	.698
68	.....	.706
69	.....	.714
70	.....	0.723
Average a	0.561	0.668

As can be seen in Table A, the values of a are not constant for any one refrigerant temperature. However, the maximum deviation between the values listed in Table 1 and the highest and lowest values obtained during the computations occurred for a refrigerant temperature of about 40 to 45 deg and amounted to about ± 10 per cent.

As is evident, the computation for the values of a is empirical. Neverthless, if a given set of values of a is used in analyzing the performance of a coil test, these same values of a can later be used to accurately predict the performance of the coil under conditions other than those for which it was tested, or accurately to predict the performance of coils of the same design but composed of different numbers of rows of tubes than the coil tested. These statements can be verified by referring to the tests in Appendix 15.

The variation in the values of a can be represented quite accurately by the use of a second degree equation; but unfortunately, as previously stated, the use of such an equation has certain drawbacks. The use of constant average values of a is justified from the standpoint that it yields a set of simple, consistent equations, and that the results obtained by means of these equations agree quite closely with the results of tests on both direct expansion and counterflow coils.

Appendix 5

Derivation of Equation 8 for Direct Expansion Coils

$$\frac{D_2}{D_1} = e^{-M}$$

Equation 1 of Appendix 1 is

$$dH_s = f_s (t - t_s)\, dA_W \quad \ldots\ldots [1]$$

Equation 2 of Appendix 2 is

$$dH_W = \frac{f_R}{B} (t_s - t_R) dA_W \quad \ldots\ldots [2]$$

Eliminating t_s between Equations 1 and 2,

$$\frac{dA_W}{dH_W}(t - t_R) = \frac{1}{f_s}\frac{dH_s}{dH_W} + \frac{B}{f_R} \quad \ldots\ldots [3]$$

From Equation 11 of Appendix 2,

$$\frac{dA_W}{dH_W} = \frac{1}{U_W (h - h_R)} \quad \ldots\ldots [4]$$

Substituting [4] into [3],

$$\frac{1}{U_W}\frac{t - t_R}{h - h_R} = \frac{1}{f_s}\frac{dH_s}{dH_W} + \frac{B}{f_R} \quad \ldots\ldots [5]$$

But

$$dH_W = -G dh, \text{ and } dH_s = -G c dt \quad \ldots\ldots [6]$$

Substituting [6] into [5] and rearranging terms,

$$\frac{dt}{dh} - \left[\frac{f_s}{cU_w\,(h-h_R)}\right](t-t_R) = -\frac{Bf_s}{cf_R} \quad \ldots\ldots [7]$$

This is a linear differential equation of the standard form

$$\frac{dy}{dx} + Py = Q$$

Solving [7], and making use of the following relationship below which is derived from Equation 3 of the text,

$$\frac{\dfrac{Bf_s}{cf_R}}{1-\dfrac{f_s}{cU_w}} = -\frac{1}{a} \quad \ldots\ldots [8]$$

the following equation is finally obtained:

$$\frac{a\,(t_2-t_R)-(h_2-h_R)}{a\,(t_1-t_R)-(h_1-h_R)} = \left[\frac{h_1-h_R}{h_2-h_R}\right]^{-\frac{f_s}{cU_w}} \quad \ldots\ldots [9]$$

But from Equation 14 of Appendix 2,

$$\frac{h_1-h_R}{h_2-h_R} = e^{\frac{A_wU_w}{G}} \quad \ldots\ldots [10]$$

$$\left[\frac{h_1-h_R}{h_2-h_R}\right]^{-\frac{f_s}{cU_w}} = e^{-\frac{f_sA_w}{Gc}} \quad \ldots\ldots [11]$$

Let

$$\frac{f_sA_w}{Gc} = M \quad \ldots\ldots [12]$$

(This is Equation 11 of the text.)

Therefore,

$$\left[\frac{h_1-h_R}{h_2-h_R}\right]^{\frac{f_s}{cU_w}} = e^{-M} \quad \ldots\ldots [13]$$

Substituting [13] into [9],

$$\frac{a\,(t_2-t_R)-(h_2-h_R)}{a\,(t_1-t_R)-(h_1-h_R)} = e^{-M} \quad \ldots\ldots [14]$$

Inasmuch as the enthalpy of an air-vapor mixture is very nearly constant for any given wet bulb temperature,

$$h_2-h_R = a\,(t'_2-t_R) \quad \ldots\ldots [15]$$

and

$$h_1-h_R = a\,(t'_1-t_R) \quad \ldots\ldots [16]$$

Substituting [15] and [16] into [14], and rearranging,

$$\frac{t_2-t'_2}{t_1-t'_1} = e^{-M} \quad \ldots\ldots [17]$$

Let

$$D_1 = t_1-t'_1 \quad \ldots\ldots [18]$$

$$D_2 = t_2-t'_2 \quad \ldots\ldots [19]$$

Therefore,

$$\frac{D_2}{D_1} = e^{-M} \quad \ldots\ldots [20]$$

This is Equation 8 of the text.

Because the difference between the initial wet bulb temperature of the air and the temperature of the refrigerant is frequently large, Equation 16 may not appear to be accurate enough to use in these circumstances. In spite of this, Equation 20, which is derived by means of [16], yields reasonably accurate results under all ordinary conditions encountered. A large number of condition curves have been drawn for different conditions by means of the surface temperature method described in the text. Then the points computed by means of Equations 1 and 8 of the text were plotted. In all cases the computed points fell very close to the condition curve, and in many cases the computed points coincided with the condition curve. Furthermore, as shown in Appendix 15, the final dry bulb temperatures computed by means of Equation 8 of the text agree closely with the results of tests on both direct expansion and counterflow water coils.

Appendix 6

Derivation of Equation 12 and Construction of Fig. 3

Equation 15 of Appendix 1 is

$$dH_w = \frac{f_s}{c}\,(h-h_s)\,dA_w \quad \ldots\ldots [1]$$

Equation 2 of Appendix 2 is

$$dH_w = \frac{f_R}{B}\,(t_s-t_R)\,dA_w \quad \ldots\ldots [2]$$

Divide [1] by [2],

$$\frac{h-h_s}{t_s-t_R} = \frac{cf_R}{Bf_s} \quad \ldots\ldots [3]$$

This is Equation 12 of the text.

Fig. 3 is constructed by plotting the enthalpy of air on the abscissa and then marking in the corresponding wet bulb temperatures. From the geometry of Fig. 4, it is possible to show that

$$\frac{s_T}{s_H}\,\frac{h-h_s}{t_s-t_R} = \cot\theta \quad \ldots\ldots [4]$$

where s_T and s_H are degrees and Btu per inch respectively.

Substituting [3] into [4],

$$\cot\theta = \frac{s_T}{s_H}\,\frac{cf_R}{Bf_s} \quad \ldots\ldots [5]$$

For the chart of Fig. 3, $\dfrac{s_T}{s_H} = 1.785$. Therefore,

$$\cot\theta = 1.785\,\frac{cf_R}{Bf_s} \quad \ldots\ldots [6]$$

Table 3 was computed by [6].

Appendix 7

Derivation of Equation 13

$$D_R = \left[1+\frac{1}{R}\right]D''$$

If the surface of a coil is dry, only sensible heat is lost by the air. The sensible heat lost by the air flowing past an infinitesimally small portion of the cold dry surface is

$$dH_D = f_s\,(t-t_s)\,dA_D \quad \ldots\ldots [1]$$

The sensible heat lost by the air is transferred through the refrigerant surface film. Inasmuch as the coil surface is dry, the sensible heat lost by the air is equal to the total heat lost, and

$$dH_D = \frac{f_R}{B}\,(t_s-t_R)\,dA_D \quad \ldots\ldots [2]$$

Dividing [1] by [2],

$$\frac{t-t_s}{t_s-t_R} = \frac{f_R}{Bf_s} \quad \ldots\ldots [3]$$

Now obviously the coil can remain dry only as long as its surface temperature is higher than the initial dew point temperature of the air. Condensation of moisture will begin at that point on the coil where the surface temperature is equal to the initial dew point temperature of the air, or

$$t_s = t''_1 \quad \ldots\ldots [4]$$

Substituting [4] into [3],

$$\frac{t-t''_1}{t''_1-t_R} = \frac{f_R}{Bf_s} \quad \ldots\ldots [5]$$

In Equation 5, t is now the particular dry bulb temperature of the main body of air when it is flowing past the point on the coil where the surface temperature is equal to the initial dew point temperature of the air. In other words, t is the boundary dry bulb temperature. Therefore,

$$\frac{t_R-t''_1}{t''_1-t_R} = \frac{f_R}{Bf_s} \quad \ldots\ldots [6]$$

$$t_R = \frac{f_R}{Bf_g} t''_1 - \frac{f_R}{Bf_g} t_R + t''_1 \quad \text{.....[7]}$$

$$t_R - t_R = \frac{f_R}{Bf_g} t''_1 - \frac{f_R}{Bf_g} t_R + t''_1 - t_R \quad \text{.....[8]}$$

$$= \left[1 + \frac{f_R}{Bf_g} \right] t''_1 - \left[\frac{f_R}{Bf_g} + 1 \right] t_R \text{.....[9]}$$

$$t_R - t_R = \left[1 + \frac{f_R}{Bf_g} \right] (t''_1 - t_R) \quad \text{.....[10]}$$

Let

$$D_R = (t_R - t_R) \quad \text{.....[11]}$$

$$D'' = (t''_1 - t_R) \quad \text{.....[12]}$$

$$R = \frac{Bf_g}{f_R} \quad \text{.....[13]}$$

Therefore,

$$D_R = \left[1 + \frac{1}{R} \right] D'' \quad \text{.....[14]}$$

This is Equation 13 of the text.

[To be continued]

Installation of Incinerator in Oil Fired Boiler

[Kalman Steiner† answers a reader's question]

A READER of HPAC writes that in the design of the heating system for a new municipal clinic, consideration is being given to a steel boiler suitable for burning oil and arranged for rear firing, with an incinerator built into the front of the boiler. The incinerator is to be provided with a firing door, ash door, and shaking grates; it is to be lined with firebrick, and the firebrick wall between the incinerator and the boiler is to be checkered to allow communication with the combustion chamber so that the refuse in the incinerator will be ignited by the oil burner. As the scheme is an innovation as far as these city health clinics are concerned, the reader asks for opinion as to the success that can be expected of the installation, and any comments about it.

In reply, the wording of the question leaves some doubt as to whether it is the intention to have the incinerator grate actually enclosed within the boiler walls, or whether it is intended to construct the incinerator as a separate unit and merely have it communicate into the boiler setting through the checkered wall. Both possibilities will be discussed.

In the first place, with either possibility it would be much better to front fire the boiler, setting the oil burner in position in what would be the ashpit of a coal fired boiler. The special incinerator grate could then be situated beyond the bridge wall of the oil burner firebox, with necessary doors provided through boiler wall and through base.

On the other hand, if it is preferred to keep the incinerator external to the boiler, it could be built as an extension from the rear of the boiler. This arrangement would not allow a great deal of heat to be transmitted through the communicating walls into the refuse on the grate. If the nature of the refuse is such that it will not sustain its own combustion but will need assistance from the oil fire, it will be better to incorporate the incinerator within the boiler walls.

The reason for front firing is two-fold. In the first place, a rear fired burner would have to buck the draft in sending a fire down the length of the boiler; that is, the flame travel would be against the normal draft and short circuiting might occur. The second point follows from the first, in that very little heat will be driven through the bridge wall into the incinerator compartment, as the flame and hot gas circulation is toward the opposite end.

If the boiler is to be fairly well loaded, and it is likely that the combustion space occupied by the incinerator will reduce the burner capacity, then the boiler setting should have enough additional pit to compensate for that loss.

†Ace Engrg. Co. Author of the book "Oil Burners."

Properties of Air-Vapor Mixtures Interpolated to Tenths of a Degree

By **William Goodman***

THE tables on the next two pages are continued from the ones published in January and February; with the January table appeared a brief explanation of them. Publication of these tables will be continued next month.

The values in Columns 3 and 4 are extremely useful for quickly finding the *actual* enthalpy (total heat) of an air-vapor mixture if its dry bulb and dew point temperatures are known. A complete discussion was given in the January, 1938, HPAC[1] of the method of using the actual enthalpy of the air for accurate computations as against the approximate methods commonly used. Although the error is generally not large, there are times when accurate computations using the actual enthalpy should be used. In such cases the equation below, which was developed in the earlier article, offers the quickest means of finding the actual enthalpy if the dry bulb and dew point temperatures are known.

$$h = s'' t + 1061w$$

where h = actual enthalpy of the mixture, Btu per lb of dry air;
t = dry bulb temperature of the air.

Values of s'', the humid specific heat of air corresponding to any given *dew point* temperature, are tabulated in Column 3. Values of $1061w$ corresponding to the *dew point* temperatures are tabulated in Column 4.

*The Trane Co. Member of Board of Consulting and Contributing Editors.

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[1] "New Tables of the Psychrometric Properties of Air-Vapor Mixtures." HEATING, PIPING AND AIR CONDITIONING, January, 1938, pp. 1-7.

Absolute Humidity and Enthalpy of Mixtures of Air and Saturated Water Vapor

Interpolated to Tenths of a Degree.
Barometric Pressure 14.696 Lb per Sq In.
All Tabulated Values are Quantities per Pound of Dry Air in the Mixture.

Temp. Deg Fahr t	Absolute Humidity Pounds w	Humid Specific Heat s'	1061w	Enthalpy of Air-Vapor Mixture Btu h	Temp. Deg Fahr t
1	2	3	4	5	6
31.0	0.003625	0.2416	3.847	11.34	31.0
.1	.003640		3.863	11.38	.1
.2	.003654		3.878	11.42	.2
.3	.003669	0.2417	3.894	11.46	.3
.4	.003684		3.909	11.50	.4
31.5	0.003699	0.2417	3.925	11.54	31.5
.6	.003713		3.940	11.58	.6
.7	.003728		3.956	11.62	.7
.8	.003743		3.971	11.66	.8
.9	.003757		3.987	11.70	.9
32.0	0.003772	0.2417	4.002	11.74	32.0
.1	.003788		4.019	11.78	.1
.2	.003804		4.036	11.82	.2
.3	.003819		4.052	11.86	.3
.4	.003835		4.069	11.90	.4
32.5	0.003851	0.2417	4.086	11.95	32.5
.6	.003867		4.103	11.99	.6
.7	.003883		4.120	12.03	.7
.8	.003898	0.2418	4.136	12.07	.8
.9	.003914		4.153	12.11	.9
33.0	0.003930	0.2418	4.170	12.15	33.0
.1	.003946		4.187	12.19	.1
.2	.003962		4.204	12.23	.2
.3	.003979		4.222	12.28	.3
.4	.003995		4.239	12.32	.4
33.5	0.004011	0.2418	4.256	12.36	33.5
.6	.004027		4.273	12.40	.6
.7	.004043		4.290	12.44	.7
.8	.004060		4.308	12.49	.8
.9	.004076		4.325	12.53	.9
34.0	0.004092	0.2418	4.342	12.57	34.0
.1	.004109		4.360	12.61	.1
.2	.004126	0.2419	4.378	12.65	.2
.3	.004142		4.395	12.70	.3
.4	.004159		4.413	12.74	.4
34.5	0.004176	0.2419	4.431	12.78	34.5
.6	.004193		4.449	12.82	.6
.7	.004210		4.467	12.86	.7
.8	.004226		4.484	12.91	.8
.9	.004243		4.502	12.95	.9
35.0	0.004260	0.2419	4.520	12.99	35.0
.1	.004278		4.539	13.03	.1
.2	.004295		4.557	13.08	.2
.3	.004313		4.576	13.12	.3
.4	.004330	0.2420	4.594	13.16	.4
35.5	0.004348	0.2420	4.613	13.21	35.5
.6	.004365		4.632	13.25	.6
.7	.004383		4.650	13.29	.7
.8	.004400		4.669	13.33	.8
.9	.004418		4.687	13.38	.9
36.0	0.004435	0.2420	4.706	13.42	36.0
.1	.004453		4.725	13.46	.1
.2	.004471		4.744	13.51	.2
.3	.004489		4.764	13.55	.3
.4	.004507		4.783	13.60	.4
36.5	0.004526	0.2420	4.802	13.64	36.5
.6	.004544		4.821	13.68	.6
.7	.004562	0.2421	4.840	13.73	.7
.8	.004580		4.860	13.77	.8
.9	.004598		4.879	13.82	.9
37.0	0.004616	0.2421	4.898	13.86	37.0
.1	.004635		4.918	13.90	.1
.2	.004653		4.938	13.95	.2
.3	.004672		4.957	13.99	.3
.4	.004691		4.977	14.04	.4
37.5	0.004710	0.2421	4.997	14.08	37.5
.6	.004728		5.017	14.12	.6
.7	.004747		5.037	14.17	.7
.8	.004766		5.056	14.21	.8
.9	.004784	0.2422	5.076	14.26	.9
38.0	0.004803	0.2422	5.096	14.30	38.0
.1	.004822		5.117	14.35	.1
.2	.004842		5.137	14.39	.2
.3	.004861		5.158	14.44	.3
.4	.004880		5.178	14.48	.4
38.5	0.004900	0.2422	5.199	14.53	38.5
.6	.004919		5.219	14.57	.6
.7	.004938		5.240	14.62	.7
.8	.004957		5.260	14.66	.8
.9	.004977		5.281	14.71	.9
39.0	0.004996	0.2423	5.301	14.75	39.0
.1	.005016		5.322	14.80	.1
.2	.005036		5.343	14.84	.2
.3	.005056		5.365	14.89	.3
.4	.005076		5.386	14.93	.4
39.5	0.005096	0.2423	5.407	14.98	39.5
.6	.005116		5.428	15.03	.6
.7	.005136		5.449	15.07	.7
.8	.005156		5.471	15.12	.8
.9	.005176		5.492	15.16	.9
40.0	0.005196	0.2423	5.513	15.21	40.0
.1	.005217		5.535	15.26	.1
.2	.005237	0.2424	5.557	15.30	.2
.3	.005258		5.579	15.35	.3
.4	.005279		5.601	15.39	.4
40.5	0.005300	0.2424	5.623	15.44	40.5
.6	.005320		5.645	15.49	.6
.7	.005341		5.667	15.53	.7
.8	.005362		5.689	15.58	.8
.9	.005382		5.711	15.62	.9
41.0	0.005403	0.2424	5.733	15.67	41.0
.1	.005425		5.756	15.72	.1
.2	.005446	0.2425	5.779	15.77	.2
.3	.005468		5.802	15.81	.3
.4	.005489		5.825	15.86	.4
41.5	0.005511	0.2425	5.848	15.91	41.5
.6	.005533		5.870	15.96	.6
.7	.005554		5.893	16.01	.7
.8	.005576		5.916	16.05	.8
.9	.005597		5.939	16.10	.9
42.0	0.005619	0.2425	5.962	16.15	42.0
.1	.005641		5.985	16.20	.1
.2	.005663	0.2426	6.009	16.25	.2
.3	.005685		6.032	16.29	.3
.4	.005707		6.056	16.34	.4
42.5	0.005730	0.2426	6.079	16.39	42.5
.6	.005752		6.102	16.44	.6
.7	.005774		6.126	16.49	.7
.8	.005796		6.149	16.53	.8
.9	.005818		6.173	16.58	.9
43.0	0.005840	0.2426	6.196	16.63	43.0
.1	.005863		6.220	16.68	.1
.2	.005886	0.2427	6.245	16.73	.2
.3	.005909		6.269	16.78	.3
.4	.005932		6.294	16.83	.4
43.5	0.005955	0.2427	6.318	16.88	43.5
.6	.005978		6.342	16.92	.6
.7	.006001		6.367	16.97	.7
.8	.006024		6.391	17.02	.8
.9	.006047		6.416	17.07	.9
44.0	0.006070	0.2427	6.440	17.12	44.0
.1	.006094		6.466	17.17	.1
.2	.006118	0.2428	6.491	17.22	.2
.3	.006142		6.517	17.27	.3
.4	.006166		6.542	17.32	.4
44.5	0.006191	0.2428	6.568	17.38	44.5
.6	.006215		6.594	17.43	.6
.7	.006239		6.619	17.48	.7
.8	.006263		6.645	17.53	.8
.9	.006287		6.670	17.58	.9
45.0	0.006311	0.2428	6.696	17.63	45.0
.1	.006336	0.2429	6.722	17.68	.1
.2	.006361		6.749	17.73	.2
.3	.006385		6.775	17.78	.3
.4	.006410		6.801	17.83	.4
45.5	0.006435	0.2429	6.828	17.89	45.5
.6	.006460		6.854	17.94	.6
.7	.006485		6.880	17.99	.7
.8	.006509		6.906	18.04	.8
.9	.006534		6.933	18.09	.9
46.0	0.006559	0.2430	6.959	18.14	46.0
.1	.006584		6.986	18.19	.1
.2	.006610		7.013	18.24	.2
.3	.006635		7.040	18.30	.3
.4	.006661		7.067	18.35	.4
46.5	0.006686	0.2430	7.094	18.40	46.5
.6	.006711		7.121	18.45	.6
.7	.006737		7.148	18.50	.7
.8	.006762		7.175	18.56	.8
.9	.006788	0.2431	7.202	18.61	.9
47.0	0.006813	0.2431	7.229	18.66	47.0
.1	.006839		7.257	18.71	.1
.2	.006866		7.285	18.76	.2
.3	.006892		7.313	18.82	.3
.4	.006918		7.341	18.87	.4
47.5	0.006945	0.2431	7.369	18.92	47.5
.6	.006971		7.396	18.97	.6
.7	.006997		7.424	19.02	.7
.8	.007023	0.2432	7.452	19.08	.8
.9	.007050		7.480	19.13	.9

[See preceding page]

Absolute Humidity and Enthalpy of Mixtures of Air and Saturated Water Vapor

Interpolated to Tenths of a Degree.
Barometric Pressure 14.696 Lb per Sq In.
All Tabulated Values are Quantities per Pound of Dry Air in the Mixture.

Temp. Deg Fahr t	Absolute Humidity Pounds w	Humid Specific Heat s'	$1061w$	Enthalpy of Air-Vapor Mixture Btu h	Temp. Deg Fahr t
1	2	3	4	5	6
48.0	0.007076	0.2432	7.508	19.18	48.0
.1	.007104		7.537	19.23	.1
.2	.007131		7.566	19.29	.2
.3	.007159		7.595	19.34	.3
.4	.007186		7.624	19.40	.4
48.5	0.007214	0.2432	7.654	19.45	48.5
.6	.007241	0.2433	7.683	19.50	.6
.7	.007269		7.712	19.56	.7
.8	.007296		7.741	19.61	.8
.9	.007324		7.770	19.67	.9
49.0	0.007351	0.2433	7.799	19.72	49.0
.1	.007380		7.829	19.78	.1
.2	.007408		7.860	19.83	.2
.3	.007437		7.890	19.89	.3
.4	.007465	0.2434	7.921	19.94	.4
49.5	0.007494	0.2434	7.951	20.00	49.5
.6	.007523		7.981	20.06	.6
.7	.007551		8.012	20.11	.7
.8	.007580		8.042	20.17	.8
.9	.007608		8.073	20.22	.9
50.0	0.007637	0.2434	8.103	20.28	50.0
.1	.007666	0.2435	8.134	20.34	.1
.2	.007695		8.165	20.39	.2
.3	.007725		8.196	20.45	.3
.4	.007754		8.227	20.50	.4
50.5	0.007783	0.2435	8.258	20.56	50.5
.6	.007812		8.289	20.62	.6
.7	.007841		8.320	20.67	.7
.8	.007871		8.351	20.73	.8
.9	.007900	0.2436	8.382	20.78	.9
51.0	0.007929	0.2436	8.413	20.84	51.0
.1	.007959		8.445	20.90	.1
.2	.007989		8.477	20.95	.2
.3	.008019		8.508	21.01	.3
.4	.008049		8.540	21.07	.4
51.5	0.008079	0.2436	8.572	21.13	51.5
.6	.008109		8.604	21.18	.6
.7	.008139	0.2437	8.636	21.24	.7
.8	.008169		8.667	21.30	.8
.9	.008199		8.699	21.35	.9
52.0	0.008229	0.2437	8.731	21.41	52.0
.1	.008261		8.765	21.47	.1
.2	.008292		8.798	21.53	.2
.3	.008324		8.832	21.58	.3
.4	.008355	0.2438	8.865	21.64	.4
52.5	0.008387	0.2438	8.899	21.70	52.5
.6	.008419		8.932	21.76	.6
.7	.008450		8.966	21.82	.7
.8	.008482		8.999	21.87	.8
.9	.008513		9.033	21.93	.9
53.0	0.008545	0.2439	9.066	21.99	53.0
.1	.008577		9.100	22.05	.1
.2	.008609		9.134	22.11	.2
.3	.008642		9.169	22.17	.3
.4	.008674		9.203	22.23	.4
53.5	0.008706	0.2439	9.237	22.29	53.5
.6	.008738		9.271	22.34	.6
.7	.008770		9.305	22.40	.7
.8	.008803	0.2440	9.340	22.46	.8
.9	.008835		9.374	22.52	.9
54.0	0.008867	0.2440	9.408	22.58	54.0
.1	.008900		9.443	22.64	.1
.2	.008934		9.479	22.70	.2
.3	.008967		9.514	22.76	.3
.4	.009000	0.2441	9.549	22.82	.4
54.5	0.009034	0.2441	9.585	22.89	54.5
.6	.009067		9.620	22.95	.6
.7	.009100		9.655	23.01	.7
.8	.009133		9.690	23.07	.8
.9	.009167		9.726	23.13	.9
55.0	0.009200	0.2441	9.761	23.19	55.0
.1	.009235	0.2442	9.798	23.25	.1
.2	.009270		9.835	23.31	.2
.3	.009305		9.872	23.38	.3
.4	.009340		9.909	23.44	.4
55.5	0.009375	0.2442	9.946	23.50	55.5
.6	.009409		9.982	23.56	.6
.7	.009444	0.2443	10.02	23.62	.7
.8	.009479		10.06	23.69	.8
.9	.009514		10.09	23.75	.9
56.0	0.009549	0.2443	10.13	23.81	56.0
.1	.009584		10.17	23.87	.1
.2	.009620		10.21	23.94	.2
.3	.009655		10.24	24.00	.3
.4	.009691	0.2444	10.28	24.06	.4
56.5	0.009726	0.2444	10.32	24.13	56.5
.6	.009761		10.36	24.19	.6
.7	.009797		10.40	24.25	.7
.8	.009832		10.43	24.31	.8
.9	.009868		10.47	24.38	.9
57.0	0.009903	0.2445	10.51	24.44	57.0
.1	.009940		10.55	24.51	.1
.2	.009976		10.59	24.57	.2
.3	.01001		10.63	24.64	.3
.4	.01005		10.67	24.70	.4
57.5	0.01009	0.2445	10.71	24.77	57.5
.6	.01012	0.2446	10.74	24.83	.6
.7	.01016		10.78	24.90	.7
.8	.01020		10.82	24.96	.8
.9	.01023		10.86	25.03	.9
58.0	0.01027	0.2446	10.90	25.09	58.0
.1	.01031		10.94	25.16	.1
.2	.01035	0.2447	10.98	25.22	.2
.3	.01039		11.02	25.29	.3
.4	.01043		11.06	25.35	.4
58.5	0.01047	0.2447	11.11	25.42	58.5
.6	.01050		11.15	25.49	.6
.7	.01054		11.19	25.55	.7
.8	.01058	0.2448	11.23	25.62	.8
.9	.01062		11.27	25.68	.9
59.0	0.01066	0.2448	11.31	25.75	59.0
.1	.01070		11.35	25.82	.1
.2	.01074		11.39	25.88	.2
.3	.01078		11.43	25.95	.3
.4	.01082	0.2449	11.47	26.02	.4
59.5	0.01086	0.2449	11.52	26.09	59.5
.6	.01089		11.56	26.15	.6
.7	.01093		11.60	26.22	.7
.8	.01097		11.64	26.29	.8
.9	.01101	0.2450	11.68	26.35	.9
60.0	0.01105	0.2450	11.72	26.42	60.0
.1	.01109		11.76	26.49	.1
.2	.01113		11.81	26.56	.2
.3	.01117		11.85	26.63	.3
.4	.01121		11.89	26.70	.4
60.5	0.01125	0.2451	11.94	26.77	60.5
.6	.01129		11.98	26.83	.6
.7	.01133		12.02	26.90	.7
.8	.01137		12.06	26.97	.8
.9	.01141		12.11	27.04	.9
61.0	0.01145	0.2452	12.15	27.11	61.0
.1	.01149		12.20	27.18	.1
.2	.01154		12.24	27.25	.2
.3	.01158		12.29	27.32	.3
.4	.01162		12.33	27.39	.4
61.5	0.01167	0.2453	12.38	27.47	61.5
.6	.01171		12.42	27.54	.6
.7	.01175		12.47	27.61	.7
.8	.01179		12.51	27.68	.8
.9	.01184		12.56	27.75	.9
62.0	0.01188	0.2454	12.60	27.82	62.0
.1	.01192		12.65	27.89	.1
.2	.01197		12.69	27.96	.2
.3	.01201		12.74	28.03	.3
.4	.01205		12.79	28.10	.4
62.5	0.01210	0.2454	12.84	28.18	62.5
.6	.01214	0.2455	12.88	28.25	.6
.7	.01218		12.93	28.32	.7
.8	.01222		12.98	28.39	.8
.9	.01227		13.02	28.46	.9
63.0	0.01231	0.2455	13.07	28.53	63.0
.1	.01236	0.2456	13.12	28.60	.1
.2	.01240		13.16	28.68	.2
.3	.01245		13.21	28.75	.3
.4	.01249		13.25	28.82	.4
63.5	0.01254	0.2456	13.30	28.90	63.5
.6	.01258	0.2457	13.35	28.97	.6
.7	.01263		13.39	29.04	.7
.8	.01267		13.44	29.11	.8
.9	.01272		13.48	29.19	.9
64.0	0.01276	0.2457	13.53	29.26	64.0
.1	.01281	0.2458	13.58	29.34	.1
.2	.01285		13.63	29.41	.2
.3	.01290		13.68	29.49	.3
.4	.01295		13.73	29.56	.4
64.5	0.01300	0.2458	13.79	29.64	64.5
.6	.01304	0.2459	13.84	29.72	.6
.7	.01309		13.89	29.79	.7
.8	.01314		13.94	29.87	.8
.9	.01318		13.99	29.94	.9

[See second preceding page]

ASME Speakers Present Data on Piping Design and Experience

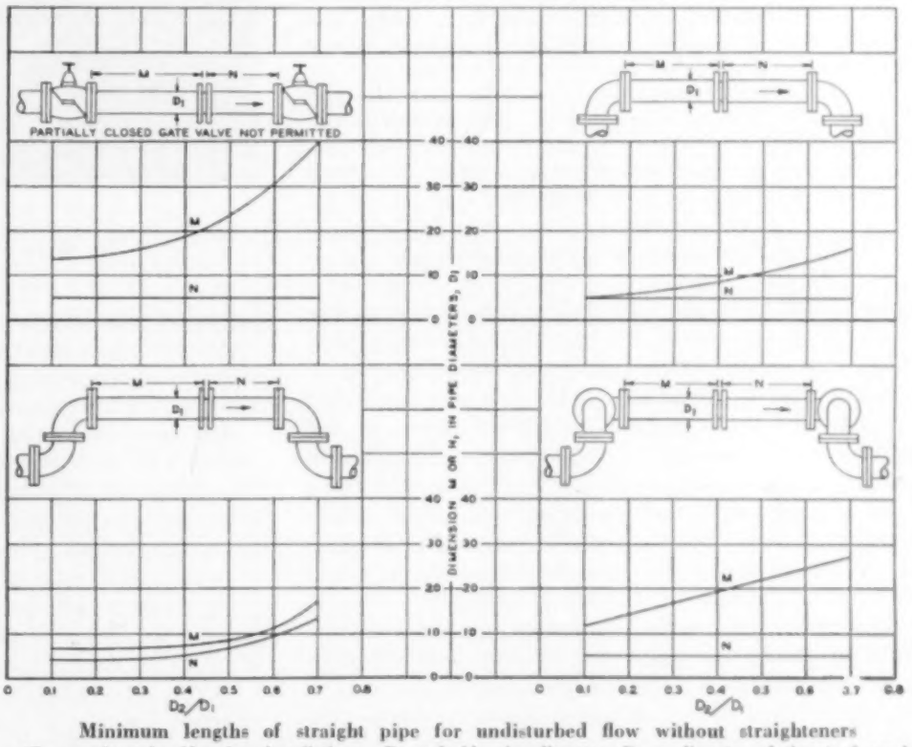
THREE papers of particular interest to piping engineers presented at the annual American Society of Mechanical Engineers meeting in December are quoted from in the following paragraphs.

Influence of Metering Equipment on Piping

Proper consideration of the question of metering by the piping designer and meter experts in the early stage of piping studies can nearly always result in a better and more economical installation than when selection of nozzle or orifice plate locations is delayed until the piping design is completed and perhaps in the process of fabrication, according to R. M. Van Duzer, Jr., The Detroit Edison Co., in his paper on influence of steam flow metering equipment on piping design.[1]

One of the factors directly related to the piping design is the nozzle or orifice plate diameter ratio, D_2/D_1; that is, the nozzle or orifice plate throat diameter, D_2, divided by the inside pipe diameter, D_1. If a diameter ratio much greater than 0.7 is used, flow through the throat is apt to be erratic over a range of steam flow, partly due to pipe wall roughness, and the use of the "estimated" flow coefficients may result in considerable error in the total quantity. On the other hand, the use of a nozzle with a low diameter ratio may result in a large net pressure drop and the use of an expensive high-differential-pressure secondary element, neither of which would be acceptable in most piping designs. The piping designer's problem then becomes one of selecting the economical line size based on the allowable overall pressure drop and the cost of the pipe, which should include as well the meter installation cost. Several cases with which the author is familiar permitted the use of pipe a size larger than that dictated by the pressure drop requirements, at some saving in cost, because a secondary metering element for a lower head could be utilized.

A second factor is that of location of the nozzle or orifice plate in the pipe line to permit satisfactory upstream and downstream flow conditions. Although much is still unkown as to the disturbing influence caused by eddies and swirls resulting from pipe bends and fittings which may be in the line ahead of the primary device, certain minimum conditions as to the amount of straight pipe before and after the nozzle have been established by experimenters. Several typical nozzle locations with different piping arrangements are shown in the drawing. The values given are those which have been established by experiment to give dependable flow coefficients. Whenever there may be doubt as to whether undisturbed flow is obtained, the use of a straightening vane in addition to the minimum lengths of straight pipe is advisable. This is particularly true where the primary element is



Minimum lengths of straight pipe for undisturbed flow without straighteners

(For nozzle and orifice-plate installations. D_1 = inside pipe diameter, D_2 = diameter of throat of nozzle or orifice plate. From ASME "Instruments and Apparatus," Part 5, Chapt. 4. Based on Figs. 1 to 5, Report of the Joint AGA-ASME Committee on Orifice Coefficients, 1935; and Figs. 27, 27-a, 28, and 29, "Durchflusszahlen von Düsen und Stauränderm," by R. Witte, *Technische Mechanik und Thermodynamik*, Vol. 1, March, 1930, p. 113.)

[1]Published in full in *Mechanical Engineering*, November, 1938.

Influence of Steam Flow Metering Equipment on Piping Design . . . . High Temperature Steam Experience . . . Use of Models in Determining Expansion Forces

preceded by bends in more than one plane. It is difficult, even with long lengths of straight pipe, to eliminate the double swirls set up.

The selection of the most concentric piece of pipe from the lot used for the line as the filler immediately preceding the primary element is a refinement in the erection of the piping system that perhaps may be difficult to justify from the accuracy gained in flow measurement but it is the practice of Detroit Edison. The selected pipe sections also are inspected for smoothness and longitudinal scoring.

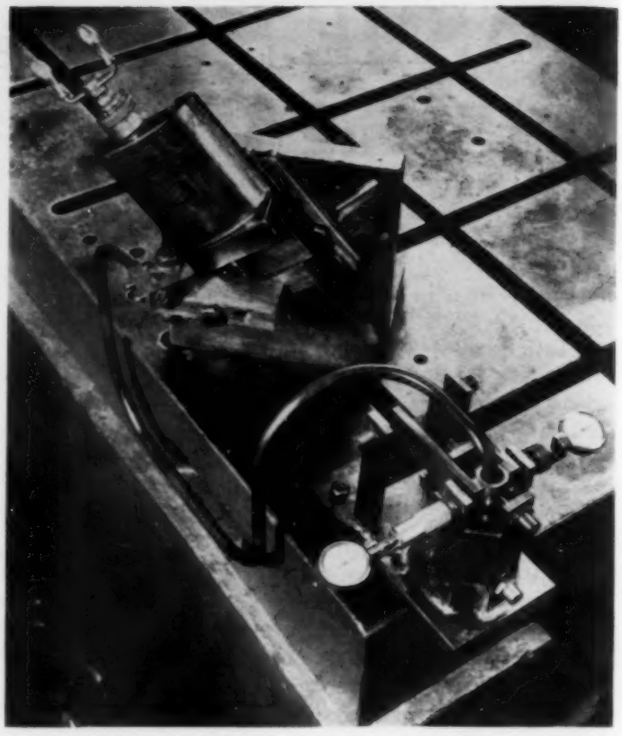
In conclusion, Mr. Van Duzer said:

1. A suitable nozzle or orifice plate diameter ratio should be selected to insure constant flow coefficients over the operating range of the meter if accuracies under plus or minus 2 per cent are to be realized. D_2/D_1 should not exceed 0.75 and preferably should be under 0.70.

2. The section of piping in which the primary element is installed should provide sufficient straight pipe upstream and downstream from the nozzle or orifice plate to eliminate swirls or eddies in the stream flow. If there is doubt as to whether undisturbed flow is obtained. straightening vanes should be used in addition to the minimum lengths of straight pipe.

3. The flow meter manufacturers should be consulted before the final piping design is fixed to insure that the best installation is obtained.

4. The most concentric and smoothest pieces of pipe should be selected to precede the primary element.



Arrangement of the test apparatus for determining expansion forces

High Temperature Steam Experience

Mr. Van Duzer and Arthur McCutchan, also of Detroit Edison, presented a paper on high temperature steam experience. This paper was a continuation of one presented in December, 1933, in which the 10,000 kw, 1000 F turbine installed by Detroit Edison was described in detail together with the results obtained with various materials used in the construction of a small 1100 F superheater and piping system. The turbine installation was dismantled in 1937 after 26,453 hours of service and the 1100 F equipment has been continued in service for the further testing of materials.

The turbine operation has demonstrated the practicability of 1000 F operation. An examination of all principal materials used in the construction of the turbine, piping, and superheater showed that with several exceptions the alloys were in good condition. Measurements made to determine creep disclosed only small amounts.

The results of 1100 F steam corrosion tests on 18 steels indicate that the scale formations offer material protection against subsequent steam attack and that the corrosion process is different in steam from that in air. A comparison of creep determinations made on four machined pipe sections—two in service at 380 lb per sq in. and 1100 F, and two in service at 380 lb per sq in. and 925 F—and laboratory specimens at the same temperature and stress tend to disprove the theory that total diametral elongation of a pipe subject to internal pressure is materially less than that indicated by tensile-creep tests.

Few changes of magnitude were noted in the piping system other than at the bolted pipe joints. Changes in the 8½ in. OD, ⅝ in. wall, low carbon, 18 per cent Cr, 8 per cent Ni tubing at the point of maximum bending stress were small. One length measurement in the horizontal plane decreased 2 mils in 20 in. and the diameter in the vertical plane increased 2 mils, indicating that a bending movement caused flattening.

The behavior of the pipe line from the superheater outlet to the turbine inlet was investigated to determine the amount of expansion and to determine any permanent change in position. The difference in position from the cold to the hot checked very well with the calculated expansion used in design. No information was obtained, however, as to any permanent change in the assembly because the line and hangers were disturbed a number of times to repair joint leaks. The whole experience with this line indicated the desirability of welded construction for trouble free operation.

One of the field position welds in the 8 in. line was cut up and examined and the tensile strength of standard pipe wall coupons taken across the weld was found to vary from 38,000 lb per sq in. at the bottom to 62,000 lb per sq in. at the top of the joint; the corresponding variation in elongation was from 2 to 6 per cent. The weld was made without a backing ring, and lack of penetration and cracks in the first bead account for the low strength. A position test weld made prior to the field weld gave corresponding tensile strengths of from 65,000 to 75,000 lb per sq in. with elongations of from 13 to 17 per cent, respectively. The Izod impact value of the test weld was 42 ft-lb as against 22 ft-lb in the field joint. The carbon content of the weld metal in both cases was 0.07 per cent. As a safety precaution, joints of this type had been provided with bolted backing up flanges in anticipation of weld embrittlement, which might have caused failure of the joint.

Models Used to Determine Expansion Forces

Determination of the expansion forces in piping by model test was the subject of a paper presented by Harold W. Semar, mechanical engineer, Westinghouse Electric & Mfg. Co.

In the design of piping, consideration must be given to the forces and stresses set up by expansion of the pipe and by movement of the end supports. In modern central station power plants where the main steam lines carry steam at 1200 lb pressure and 925 F, this problem is especially important.

The design of the piping system, therefore, requires a means of predicting the expansion stresses and forces so that sufficient flexibility can be provided with a minimum of bends and extra pipe length. When the pipe lies in a single plane the calculation can be readily made, but when the pipe is three dimensional the calculation is long and tedious.

An accurate solution of complicated piping systems can be made, however, by tests of a scale model. This method is now in use in checking the forces exerted on large steam turbines by the inlet and exhaust piping. The method consists in fixing one end of the model in a slide which can be moved a measured amount, and measuring the forces at the other end by means of a fixture which holds that end rigidly in place and permits measurement of six forces in three co-ordinate planes, which are the equivalent of forces in co-ordinate directions plus moments in co-ordinate planes. The slide of the movable end is placed so that its direction of motion coincides with the direction of the pipe expansion.

National Gallery of Art To Be Air Conditioned

WHEN the new National Gallery of Art opens its doors to the public next year in Washington, D. C., one of the world's most valuable collections of masterpieces will go on exhibit under the benign influence of a complete system of air conditioning. Conceived and made possible by the late Andrew W. Mellon, the gallery has been under construction since 1937. The architect is John Russell Pope.

Air conditioning has dual benefits to an art gallery or museum, Wm. B. Henderson, of the Air Conditioning Manufacturers' Association, points out. First and most obvious is the comfort it provides the staff and the visitors. But even more important to such an institution is the preservative effect of uniform temperatures and humidities on irreplaceable art objects, for deterioration of art possessions under varying humidities and temperatures such as we have in this country is a chief concern of art directors.

The low humidities prevailing in the winter months cause parchment, paint, wood, and textiles to become brittle and crack. On the other hand, when humidities are excessive in summer, the growth of molds, fungus, and mildew is stimulated. And the daily swings of temperature and humidity impose a strain on the structure of tapestries, furniture, and paintings which eventually leads to their destruction.

What is called "bronze disease" by J. Francis McCabe, superintendent of the Art Institute of Chicago, attacks bronze antiques excavated in Greece and Macedonia and, in time, eats away the surface of the metal. Mr. McCabe describes this disease as a fungus growth which apparently can be overcome only by two methods: by the concentrated application of heat rays or by air conditioning. Old armor is affected in much the same way by a rust growth.

At the Frick museum in New York, which has employed air conditioning for three years, Dr. F. Mortimer Clapp, the director, reports that air conditioning has completely eliminated "bloom" from the surface of oil paintings. This bluish film of moisture, which shows up on varnished surfaces in damp weather, not only detracts from the appearance of a painting, but is a signal to art directors that they must not apply any paint or other preservative until the "bloom" has been removed by a change to drier weather.

Another difficulty which is overcome by air conditioning arises from the fact that most museums are situated in the hearts of large cities, where the outside atmosphere is laden with dust and sulphurous acid gas from chimneys. Dust is a most destructive agent to all fabrics, while sulphurous acid attacks metals. In the Frick museum, Dr. Clapp describes a state of cleanliness which is the envy of art directors—his attendants do not need to dust off their exhibit pieces more than once a year. And the acid content of New York air is neutralized by operating the conditioning system with a slightly alkaline content in the air washer.

A model of the new National Gallery of Art Underwood & Underwood

Wide Variety of Piping Serves New Steel Plant

A summary of the many piping services and materials used at the new Irvin works of Carnegie-Illinois Steel Corp., based upon information made available through the courtesy of Floyd Woumans*

IF placed end to end, the piping for the new Irvin works of Carnegie-Illinois Steel Corp., in the Pittsburgh district, would stretch for 60 miles. The layout and installation, done by Power Piping Div. of Blaw-Knox Co., involved one of the largest industrial piping contracts ever undertaken.

Piping was started when ground was broken, and finished with completion of the plant. Individual units were completed on schedule to allow sections of the plant to operate independently. Shop prefabrication of the piping avoided costly delays in the field, cut costs of erection, and improved appearance of the work.

This required specialized engineering and close planning and co-ordination of work. The field force at times numbered as many as 1600 men and 40 designing engineers. Thirty-five electric and 53 acetylene welding machines were in operation during a large part of the job.

Steel, wrought iron, lead, copper, rubber, and glass piping are included, with sizes ranging up to and including 48 in. diameter; the systems convey steam, water, air, gas, palm oil, acids, and lubricants. Among other products, the plant produces finished sheets and tinplate from steel slabs, involving an 80 in. continuous hot strip mill, a cold reducing division, hot and cold reduced finishing departments. Each step in the process is assisted by one or several forms of piping.

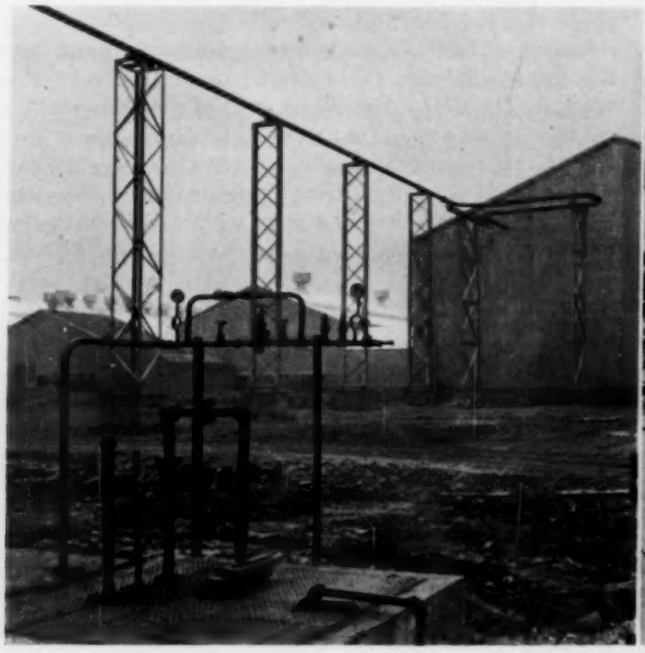
Steam is generated in two waste heat boilers, utilizing the heat from three slab heating furnaces or coke oven gas, and in two boilers, which are stoker fired with coke breeze or fired with coke oven gas. About 10 miles of piping carries steam from the boilers to sections of the plant where it is used for cleaning, melting palm oil, and other heating and operating purposes. The steam leaves the boilers under 200 lb pressure through 12 in. mains traversing the full length of the mill. Underground lines run in tile conduit with glass wool insulation; overhead lines are supported by roof trusses and pass between buildings 50 ft above ground. Expansion U bends are placed every 250 ft. Steam condensate is trapped and discharged into flash tanks which empty into storm water conductors.

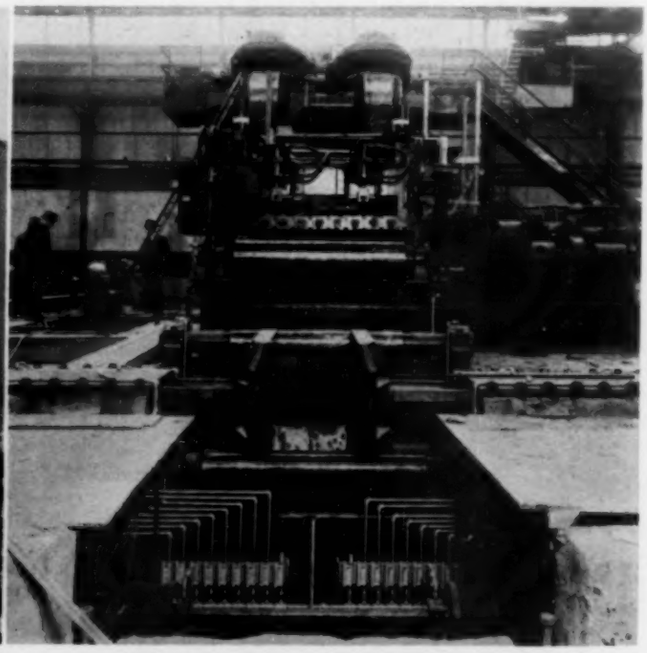
A specially constructed pumping station equipped with three pumps having a total capacity of 25,500 gpm and with screening and liming apparatus, takes water from the Monongahela river through a 42 in. line for a distance of about a mile to a reservoir 425 ft above the river. From this reservoir, a 48 in. pipe line supplies, by gravity, the entire mill. Part of the water is taken from the reservoir to a filtration plant, from which it is supplied to the mill through a 30 in. line. City water from adjacent Clairton is also furnished through an 8 in. line for drinking purposes, thus providing the plant with raw, filtered, and drinking waters.

The raw river water, after liming and screening, is used for spray cooling of rolls during rolling, for cooling lubricants on pumps and other machinery, and for the fire protection system.

*Chief Engineer, Power Piping Div., Blaw-Knox Co.

Left—An acid unloading station, showing also a 12 in. steam line crossing a 750 ft open court between buildings on 60 ft steel towers . . . Right—The piping for a pressure grease lubricating system





Filtered water is piped parallel to the raw water throughout the plant, and is used in the hydraulic systems, for making pickle baths, cooling bearings, and wherever water free from foreign matter is required. Pressures in the hydraulic systems range from 600 to 3500 lb per sq in. and the piping is all electric welded. Water and hydraulic lines contain about 40 miles of piping, all of which are installed with double loops around each building in order to insure continuous service in case of breaks.

It is thought that the descaling system in this mill operates at the highest pressure used to date. The nozzle operating pressure at all five descaling stations is 1350 lb per sq in. and the pump shut-off pressure is 1600 lb. The accumulator is of the air bottle type and is designed for a pressure of 2000 lb per sq in.

Compressed air is supplied by three compressor stations containing a total of five compressors. Air lines are looped around every building of the mill in such a manner that air can be provided at any spot by any of three stations, separately or simultaneously. Air pressures range from 100 to 1500 lb per sq in. Chief use is to control pressures on the pneumatic-hydraulic systems.

Coke oven gas is drawn from a line running between other company properties in Clairton and Homestead by means of two 24 in. lines which run to 20 in. welded overheads passing through roof trusses in the buildings and underground mains outside.

Natural gas lines contain more than a mile of underground 12 in. pipe connecting with the natural gas supplies of the company's other mills in the vicinity. In the buildings it also runs overhead through roof trusses.

Palm oil—used in cold reducing, pickling, and tinning—is unloaded from tank cars in the yard and piped to a 50,000 gal storage tank. A steam line parallels and is wrapped with each palm oil line to maintain the proper flow temperature. A reclaiming system requiring rubber, glass, and copper piping, as well as rubber valves and fittings, is installed to recover the palm oil.

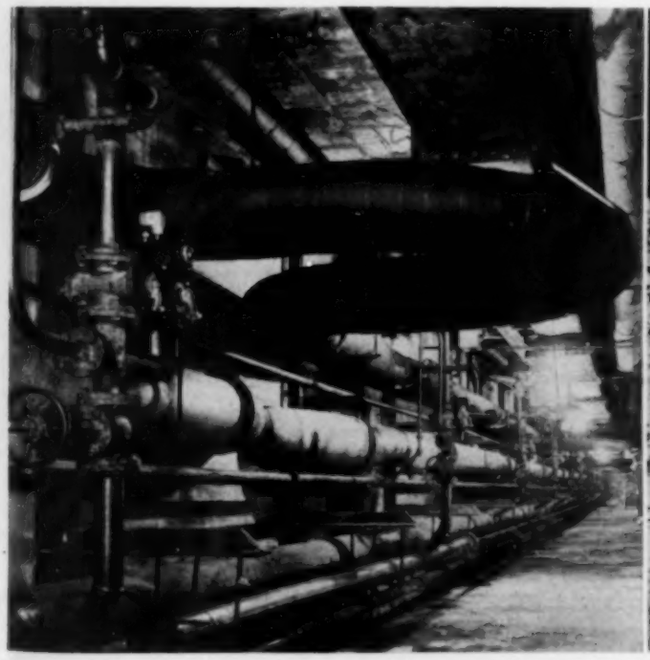
A mill of this size and type requires the extensive use of various industrial acids for use in pickling and for the oil recovery system. There are four central storage tanks for the sulphuric acid used in pickling, having a total capacity of 200,000 gal. The white pickling department alone requires an acid storage of 50,000 gal capacity, and the palm oil treating and tinning departments contain a battery of four rubber lined tanks set up with all rubber piping, fittings, and rubber lined pumps. The tinning department also contains a hydrogen evolution plant which requires piping of practically every major type of pipe material. A central neutralizing plant receives acid sewage through a 12 in. rubber lined steel pipe prior to discharge with other sewage.

Perhaps, because of their function, the lubricating systems present a more outstanding demonstration of the importance of piping to a steel mill. Nearly all types of oil and grease systems of lubrication are employed.

Four separate pressure systems are used in one installation for the lubrication of the main mill motors and motor generator sets, the reduction gear drives, and the pinion stand and backup roll bearings. These systems furnish flow lubrication to all gear meshing points and bearings and have a capacity of about 50,000 gal of lubricating oil. Each system is provided with filtration equipment and reclaiming machinery for the lubricating oils.

The installation incorporates centralized electric control panels and provision for the automatic supervision of the operation of each system. About 100 tons of pipe in sizes up to 16 in. in diameter were installed in these systems alone. Lubrication piping utilized welding and bending wherever possible, minimizing the use of fittings.

Left—Piping in tin mill tunnel; 28 different pipe lines under the tin mill convey steam, water, oil, acids, gas, soda solution, and air . . . Right—View of 20 in. welded gas line rising over 80 ft of earth and rock to source of supply



Warm Air System Heats Giant Plane

PICTURE an airplane so large that it has an inside hull volume equal to that of a five room house including basement—an airplane that can carry more than 80 persons and requires a heating system that will produce nearly five times as much heat as the heating system in a seven room house. That's the giant 74 passenger Boeing 314 Clipper, six of which are being built by the Boeing Aircraft Co., Seattle, Wash., for the transoceanic routes of Pan American Airways.

The luxurious new Clipper is designed to provide safe, rapid and comfortable transportation across both of the major oceans of the world, the Atlantic and the Pacific. With a gross weight of more than 41 tons, the Clipper has a wing span of 152 ft and a length of 106 ft. There are two full decks in the hull proper, and 18 separate compartments which provide commodious accommodations for 74 passengers in the daytime and 40 at night, in addition to the crew of eight. Cargo holds have a capacity of more than 10,000 lb of mail and express.

Exhaust Pipe Stoves Heat Air

Among the many problems of its design was an adequate and dependable heating and ventilating system. The finished airplane, the first three of which have been delivered to Pan American, includes a warm air system that derives its heat from "stoves" placed around the exhaust pipes of two of the four engines, automatically controlled by electric thermostats, and a ventilation system which provides an ample supply of air for all compartments.

The heart of the heating system is the four stoves that encircle the exhaust pipes of the two 14 cylinder 1500 hp engines on the port side of the airplane. While both of the port side engines are used, either one can supply sufficient heat for the whole system under the most severe conditions. Each of the stoves is rated at 100,000 Btu per hr, making a total of 400,000 Btu per hr available for the heating system. The principle of the heating stoves is to circulate outside air around the hot exhaust stacks of the engines. These stoves are in the form of shrouds concentric around the exhaust stacks which extend along the ceiling inside the engine nacelle. The stacks themselves are made of a nickel alloy, and the shrouds are shaped and spotwelded from stainless steel. Inspection doors are provided.

Air is rammed by the speeding airstream into the stoves and heated, after which it passes into a chamber to be mixed with cold outside air that is scooped in from the under side of the wing. The air temperature is regulated by a set of thermostatically controlled dampers. From the mixing chamber the warm air passes into a plenum chamber and thence into ducts to the various compartments in the airplane.

Warm Air Enters at Ceiling

Warm air enters each room on the passenger deck through diffusing grilles in the ceiling. Spent air is forced to the floor where it enters ducts and is vented overboard through the risers in the side walls; this is to prevent a layer of cold air along the floor. The flow of air through the ventilating system, 2500 cfm, is sufficient to change the air in the plane completely about every three minutes.

There are also individual cold air ventilators controlled manually by the passengers, this air being furnished from the same air scoop that serves the warm air system.

A typical 10 passenger compartment has two warm

air inlets, seven cold air inlets, and four spent air outlets. In such a compartment there are two triple seats facing each other on one side of the room, and two double seats on the other. These 10 seats make up into six upper and lower berths for night travel, each of which has its own light, outside cold air duct, and steward's call button arranged on a little panel.

Although the use of modern metal alloys in exhaust pipe construction is believed to virtually eliminate the possibility of cracking or burning through, there are double safeguards which prevent carbon monoxide gas from entering the cabin, in the event a break should occur. In the first place, there is a negative pressure in the exhaust pipe, with respect to the outside air in the stove, so that in effect air would leak from the stove into the exhaust rather than vice versa. Furthermore, the mixing and bypass dampers are so designed that there is always a constant flow of air through the stoves to eliminate overheating. A constant supply of air is taken through the stoves at all times, and when the heated air is not used for heating the cabins, it is bypassed out into the slip stream outside the ship.

CO Detector Samples Air

An additional safety feature is a CO detector that samples the air from the inlet duct into the cabin and automatically closes the dampers, shutting off the heat entirely from the cabin, if carbon monoxide is present. The mixing bypass dampers are arranged so that if the carbon monoxide detector acts, the heat is not only shut off entirely from the cabin, but an outside air damper is opened wide, so that there is a full supply of outside air to the cabin immediately and continually until the system is changed over by the operator. At the same time it flashes a warning light on the instrument board of the flight engineer, who can cut off the affected pair of stoves from the heating system. This done, the system can return to normal operation using the stoves of the other engine.

The carbon monoxide detector unit consists essentially

In the design of the new 74 passenger Boeing Clipper —six of which are being built for Pan American Airways—the engineers were faced with the problem of providing heating and ventilation for more people than have before been carried in one airplane. The system must be adaptable for the cold of the North Atlantic, the warmth of the South Pacific, and flight conditions that may change very rapidly . . . Air is heated by four stoves encircling the exhaust pipes of the two port engines, each of the stoves being rated at 100,000 Btu per hr. The features of the heating and ventilating system and its control are described briefly

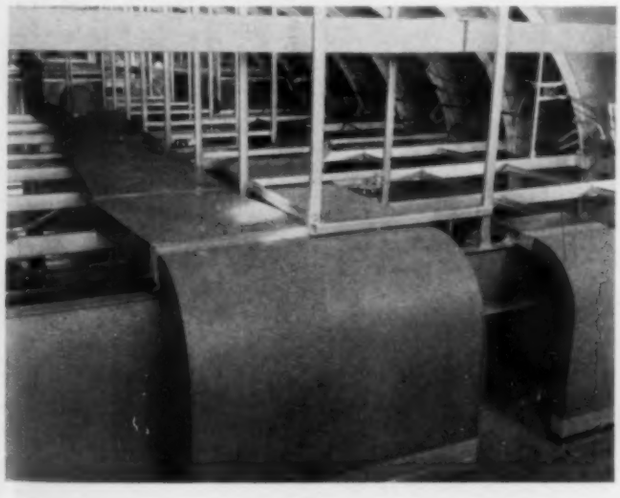
of a blower that draws a continuous sample of the incoming air from the inlet duct to the passenger compartments, into a cell where CO (if present) is converted chemically into CO_2. Parallel courses in this cell are filled with an active chemical and an inactive pumice substance. The active chemical is a granular mixture of manganese dioxide and copper oxide which serves as a catalyst for the conversion reaction to CO_2, if CO is present in the sample air. A series of thermocouples measures the difference in temperature between the active and inactive parts of the cell when the reaction takes place and actuates an automatic relay which over-rules the temperature controls and operates the damper motor to shut off all warm air from the system.

There is also another device to protect the heating system in the event of a serious failure of an exhaust stack. This is an emergency spill directly in back of each stove, consisting of a valve which can close the passage to the mixing chamber and open an outlet in the top of the nacelle. This is controlled by a fusible metal latch which will melt if the heat becomes excessive.

Heating System Control

Automatic control of the heating system is vested in four detent type electric thermostats, two of which are situated in the warm air inlet as pilot instruments, and

Part of the air distributing system in the Clipper. From the mixing chamber and its automatically controlled dampers, the warm air enters a plenum chamber, then goes to each passenger compartment through these overhead ducts in the "attic" of the Clipper. This view is looking aft



One of the 10-passenger compartments in the Clipper. Note the warm air diffusing registers in the ceiling. Warm air, entering here, forces spent air out at floor level. The window and individual ventilator panel near the ceiling serves the upper berth. It includes an outside air duct, light and call button.

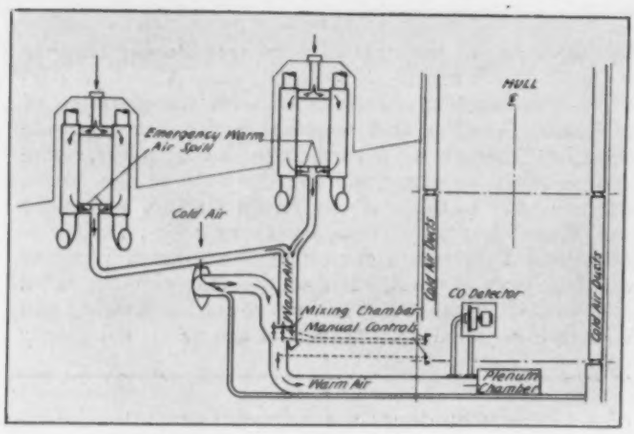


Diagram of the Clipper's heating and ventilating system. The view is looking down from above, showing the left wing and the two portside engine nacelles.

two in the spent air duct acting as room control instruments. The first two are primarily for the protection of the system against excessive heat, while the warmth of the passenger cabins is regulated by the controls in the spent air duct. The four thermostats control the motor which opens and closes the dampers.

The inlet thermostats remain at a fixed setting and their main purpose is to protect the system from extremes of temperature. They take charge only if the temperature of the air coming into the cabins tends to drop below 60 F or goes above 120 F for any reason. Due to the large volumes and high velocity of the air used, the spent air temperature in the outlet risers is practically identical with that of the air circulating in the cabin, so the two thermostats in the spent air duct actually control cabin air temperature. They have an easily adjustable setting. The bimetal element magnetic detent thermostats are used so that the instruments will definitely hold contact until the temperature differentials of the instruments are met, and will not be affected by the banking, climbing, or tipping of the ship. Subject to the supervision of the thermostats, the heat control dampers are operated by a shaded coil damper motor.

In the event of a failure of the automatic control system, the steward has a set of manually operated controls in the galley which over-ride it.

Contributing much to the comfort and beauty of the Clipper's interior are the wall coverings and soundproofing materials which have insulating qualities.

N. C. Price, chief of the development unit of Boeing's engineering department, was in charge of the development of the Clipper's heating and ventilating system.

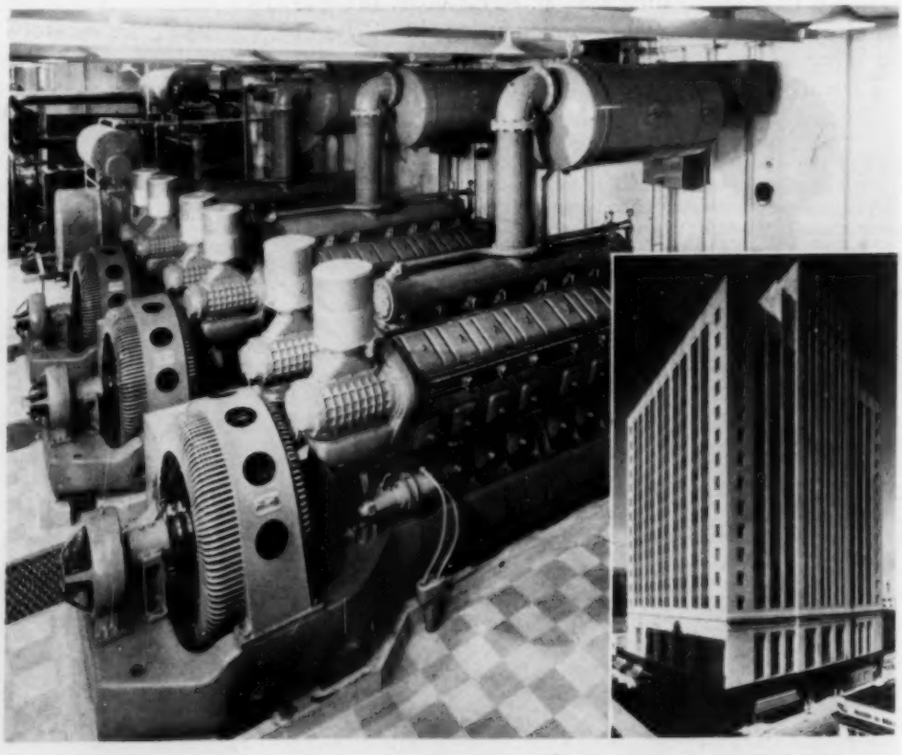
Office Building Has Diesel Power Plant

Said to be the largest office building to depend entirely for all its light and power requirements on a diesel power plant, the new Alfred I. du Pont building, Miami, Fla., has three 1050 hp, 16 cylinder, 2 cycle diesels and an auxiliary engine for the night and Sunday load which is an 8 cylinder, 4 cycle unit rated at 225 hp. Each diesel unit is complete in itself with integral blowers, unit injectors for each cylinder, attached water lube and fuel pumps. The piping for all engines is installed on the unit system and is carried in trenches with gratings for complete accessibility.

One of the interesting points in connection with the installation is that all four engines are electrically started, a 64 volt electric starter being used for the three main engines and a smaller unit for the auxiliary engine. Power to operate the starters is provided by eight 8 hr capacity batteries rated at 385 ampere hours, which batteries also supply electricity for emergency lighting throughout the power plant should all engines fail.

The building is air conditioned and the 17 story structure includes stores, banking rooms, and offices. There is an adjoining 400 car garage. The diesel installation supplies all power and lighting requirements, including that for the air conditioning and for the elevators.

The diesel and air conditioning equipment is situated in a soundproof room on the ground level which has a 2½ in. blanket of soundproofing attached to the walls and ceiling over which is laid perforated blocks.



The three 1050 hp diesels which supply power for air conditioning, elevators, lighting, etc., at the new Afred I. du Pont building in Miami, which is shown in the inset

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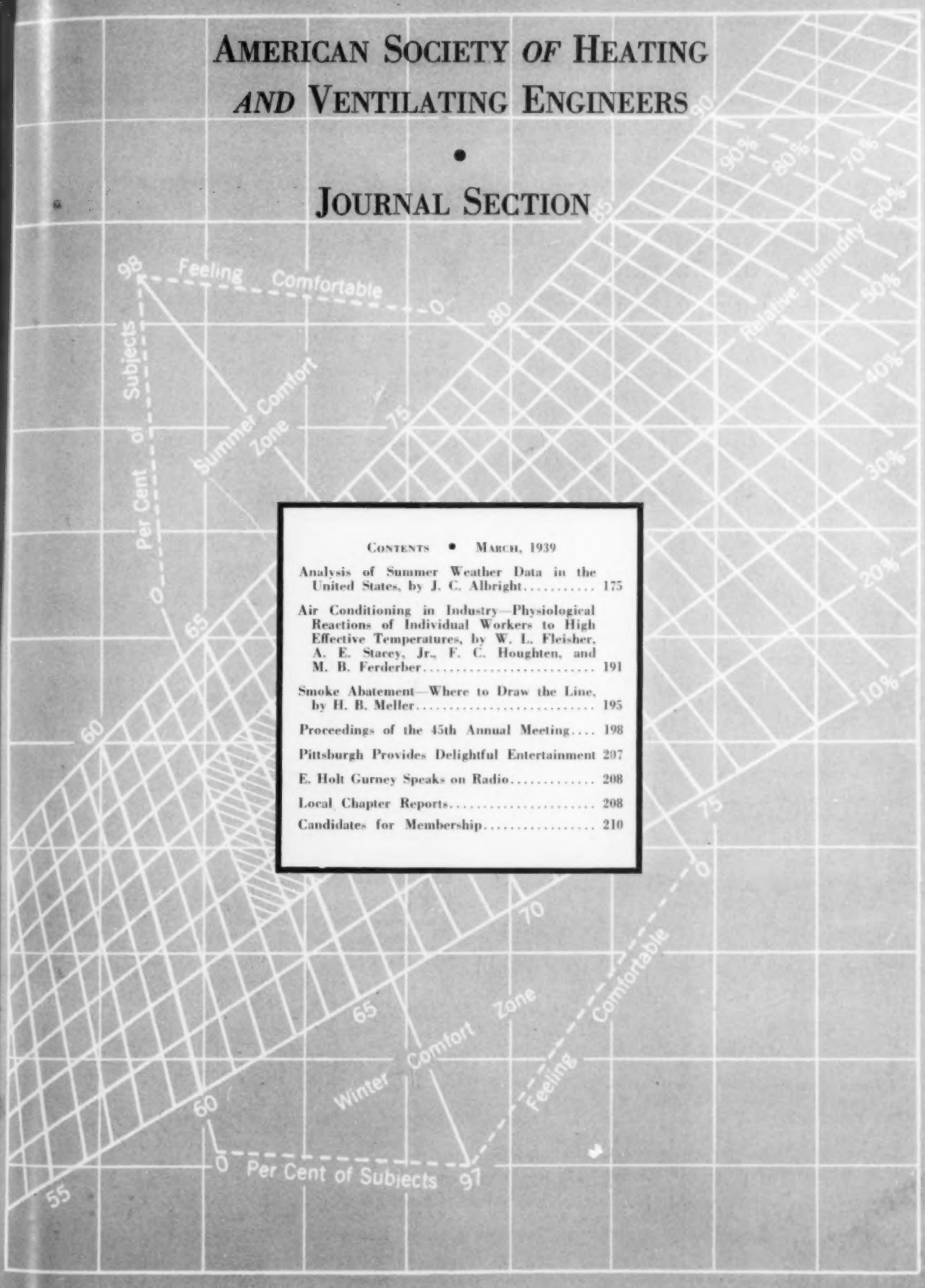

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Analysis of Summer Weather Data in the United States

By J. C. Albright,* New York, N. Y.

IN modern necessities developed by the mechanical arts section of industry, there are many heat exchange and conversion problems in which atmospheric air is involved. The most common, although luckily not the most sensitive to the atmospheric conditions, is the automobile. The density of the air affects the proper mixture for combustion, the moisture content of the air varies the power obtainable from the individual fuel, while the temperature of the air affects the dissipation of heat from the radiator. Similarly, the operation of all other fuel burning apparatus for the production of mechanical or electrical energy is affected by the pressure, temperature and moisture condition of the atmosphere. Such fuel burning devices are not usually sufficiently sensitive to the atmospheric conditions to warrant readjustment hourly, or even daily, to meet changed conditions.

On the other hand, heating of buildings in the winter, and cooling of them in the summer, not only are affected by the changes in atmospheric conditions, but an immediate readjustment of the apparatus involved is required to compensate for them. The important variables for which correction must be effected are, in the order of their importance, wet-bulb temperature, dry-bulb temperature, dew-point temperature, wind velocity and sunshine. As the barometric pressure at any one location varies through only narrow limits, individual adjustment to compensate for changes in it is not required. Precipitation is of importance only in its resultant effect upon temperature and moisture content of the air. Specialized problems affected by the quality of the atmosphere include the production of textiles, printing, atmospheric water cooling, painting and food production, to name only a few.

In some of the cases mentioned, the correction of the apparatus to care for variable qualities in the atmosphere involves merely an adjustment of the equipment as originally furnished and the design would be the same regardless of the section of the country in which it was to be used. Automobiles and fuel burning equipment come under this classification. In other problems, it is necessary to design the equipment for the specific installation, adjusting the initial size or character of the apparatus so that it will perform acceptably under the extremes of conditions to be expected, while keeping the investment to the minimum possible figure. A simple example is that one would not buy a fur-lined overcoat in preparation for a winter in Florida.

Since the variations in the different weather factors affecting such designs are great, universal rules for design applicable over the entire country are impossible. Furthermore, since a variation in one criterion is not accompanied by a proportional change in others for the different sections of the country, knowledge of the expectancy in one factor does not permit fixing the values of the other variables to be used in a design. As an instance of the first statement, wind velocities of 120 mph have been experienced in certain sections of the country, yet it would be impractical to build all structures capable of withstanding such a velocity. On the second premise, air conditioning equipment designed for a theater in Cleveland need not be of as large capacity as for the same size theater in New Orleans, yet, if the designs were based only on the dry-bulb temperatures, the same installation would be made in both.

Values of each of the factors characteristic of that location must be used in determining a design, these values to be based upon a forecast of their probable recurrence during the life of the equipment. It is the purpose of this paper to analyze the expectancy of occurrence and characteristics of those variables in weather for the summer season that are of particular importance in design, with a view to furnishing the designer with a more satisfactory understanding and measure upon which to base the design, thus permitting the optimum result to be obtained. The bulk of the analysis is devoted to temperatures as being most important in present design practice, and the dry-bulb, wet-bulb and dew-point temperatures are considered simultaneously because of their interrelation. Wind analysis and solar radiation are treated separately as fully as their present usage in design warrants.

Temperature Analysis

Sources of Data

Available for analysis of the expectancy in weather data are records obtained by both the Climate and Crop Weather, as well as the Aerological Divisions of the United States Weather Bureau. The Climatological records are published principally for the benefit of the public. The Aerological records are utilized for immediate weather analysis, to permit bulletins to be furnished to the aviation industry, but no accumulations of records are published by this division.

The best known of all the publications of the Climate and Crop Weather Division is the monthly summation of weather data, Meteorological Form No. 1030, such as is shown in Fig. 1 for July, 1933, in Pittsburgh. This information is assembled and published locally at approximately 200 stations located in cities throughout the United States. From it can be obtained daily data on the temperatures at noon local time and at 7:30 A. M. and P. M., 75th Meridian time. Note that since 75th Meridian time is Eastern Standard Time, this means that the morning and evening readings are at 4:30 o'clock in San Francisco, 6:30 in Chicago, and 5:30 in Denver.

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Form No. 1030—Met'l.

U. S. DEPARTMENT OF AGRICULTURE, WEATHER BUREAU

MONTHLY METEOROLOGICAL SUMMARY

Station, PITTSBURGH, PA. *75th meridian time* *Month,* JULY, 1933

Date	Temperature (°F.) Thermometers over roof, 353 feet above ground							Moisture								Wind			River stage, feet
	Extremes		Mean	Departure from normal	Dry bulb			Relative humidity, per cent			Vapor pressure, local noon	Precipitation, inches*				Max. velocity, miles per hour	Direction of max. velocity	Per cent of sunshine†	
												Total		Snowfall, unmelted					
	Max.	Min.			8 a. m.	Local noon	8 p. m.	8 a. m.	Local noon	8 p. m.		8 a. m. to 8 p. m.	Mid. to mid.	8 p. m. to 8 p. m.	Depth on ground 8 p. m.				
1	89	73	81	+ 7	76	88	78	68	52	72	.684	.06	.06	0	0	32	n.	72	10.4
2	80	64	72	− 2	72	71	70	85	99	95	.732	1.23	1.23	0	0	18	ne.	9	10.4
3	74	59	66	− 8	62	66	71	74	70	48	.448	0	.01	0	0	32	e.	59	10.6
4	82	54	68	− 6	61	77	76	75	39	37	.277	0	0	0	0	16	n.	96	11.5
5	81	58	70	− 4	64	77	76	67	33	35	.310	0	0	0	0	19	nw.	98	11.1
6	85	56	70	− 4	65	79	81	63	31	32	.298	0	0	0	0	15	w.	97	10.9
7	88	62	75	+ 1	71	85	83	54	31	31	.360	0	0	0	0	15	sw.	95	10.7
8	86	69	78	+ 4	74	86	75	52	34	66	.417	.03	.03	0	0	19	nw.	35	10.5
9	85	68	76	+ 2	72	80	80	79	63	57	.638	0	0	0	0	15	n.	71	10.3
10	84	61	72	− 2	66	80	80	77	37	29	.373	0	0	0	0	15	n.	82	10.3
11	85	62	74	− 1	69	80	80	51	31	25	.310	0	0	0	0	17	ne.	100	10.2
12	83	62	72	− 3	68	81	77	61	37	42	.387	0	0	0	0	15	e.	87	10.0
13	81	64	72	− 3	68	78	76	61	38	42	.373	0	0	0	0	20	se.	100	10.0
14	84	62	73	− 2	66	80	77	56	29	38	.298	0	0	0	0	17	se.	85	9.9
15	85	65	75	0	68	85	68	68	36	88	417	.34	.34	0	0	27	w.	27	10.0
16	80	62	71	− 4	65	78	70	90	59	76	.575	.41	.41	0	0	26	nw.	41	10.0
17	79	60	70	− 5	64	74	76	78	48	39	.402	0	T.	0	0	13	w.	99	10.0
18	83	60	72	− 3	67	79	75	62	42	44	.417	0	.02	0	0	15	sw.	68	10.0
19	89	63	76	+ 1	71	83	82	64	37	43	.442	0	0	0	0	15	sw.	96	10.2
20	91	65	78	+ 3	72	86	86	69	32	39	.402	0	0	0	0	14	sw.	100	10.2
21	94	71	82	+ 7	75	91	87	72	31	40	.448	0	0	0	0	14	sw.	81	10.1
22	96	66	81	+ 6	79	93	82	59	32	49	.499	.42	.42	0	0	41	nw.	61	10.1
23	98	71	84	+ 9	77	94	89	65	35	42	.575	0	0	0	0	18	s.	100	9.9
24	91	70	80	+ 5	77	88	73	66	48	88	.638	.30	.33	0	0	26	n.	55	9.8
25	79	68	74	− 1	70	75	73	90	80	78	.684	0	0	0	0	15	n.	1	10.2
26	70	67	68	− 7	67	70	68	71	74	84	.536	.04	.04	0	0	12	ne.	0	10.1
27	82	64	73	− 2	66	76	77	88	67	57	.595	0	0	0	0	10	sw.	36	10.2
28	87	63	75	0	68	81	82	84	52	49	.536	0	0	0	0	18	sw.	77	10.1
29	88	68	78	+ 3	74	78	85	82	73	50	.707	.35	.35	0	0	30	sw.	97	10.2
30	90	73	82	+ 7	76	86	85	76	59	55	.732	0	0	0	0	19	sw.	53	10.2
31	93	75	84	+ 9	77	90	86	83	49	57	.707	0	0	0	0	15	sw.	96	10.4
Mean	85.2	64.7	75.0	+0.4	69.9	81.1	78.2	70.6	43.4	51.9	.491	Total 3.15	Total 3.21	Total 0	Blank	Blk	Blk	Mean 70	Mean 10.3
Normal	.....	.....	74.6	Blank	.....	.....	.....	75	54	60	.....	Blank	4.05	0.0	Blank	Blk	Blk	64	.....

Fig. 1—Monthly weather analysis as published by the Climate and Crop Weather Division of the U. S. Weather Bureau

COMPARATIVE DATA AND EXTREMES

Month	Temperature: Average daily maximum	Average daily minimum	Average	Absolute highest	Year	Absolute lowest	Year	Precipitation: Average total	Greatest in 24 hours	Year	Average snowfall	Greatest snowfall in 24 hours	Year	Relative humidity, per cent: 8 a. m.	Hour—local time	8 p. m.	Sunshine: Total hours	Per cent	Wind: Average hourly velocity	Prevailing direction	Highest velocity	Direction highest velocity	Year	Average number of days: Clear	Partly cloudy	Cloudy	Rain, .01 or more	Snow (trace or more)	Thunderstorms	Dense fog	Max. temp. 90° or above	Minimum temp. 32° or below	Minimum temp. 0° or below	Station Pressure 29.00 inches +
Length of record, years	50	50	50	50	50	50	50	62	63	63	49	41	41	46	18	46	37	37	29	63	61	61	61	63	63	63	63	54	48	41	50	50	50	61
January	38.8	23.7	31.2	75	1906	− 12	1875	2.97	2.34	1884	8.6	11.2	1914	79	68	72	.96	32	11.9	w.	56	w.	1928	4	9	18	15	14	0	2	0	23	.1	.123
February	39.9	23.8	31.8	77	1900	−20	1899	2.54	2.01	1887	7.5	11.0	1910	79	68	71	112	37	11.8	nw.	49	w.	1923†	4	9	15	14	13	0	1	0	21	1	.125
March	48.6	31.3	40.0	94	1929	1	1900	3.08	2.04	1908	5.7	15.0	1908	78	62	65	168	45	12.2	nw.	54	w.	1920	6	10	15	15	11	2	1	0	18	0	.119
April	60.6	41.3	51.0	90	1925	11	1923	2.96	2.40	1901	2.1	12.7	1901	72	56	60	178	50	11.6	nw.	53	w.	1909	7	10	13	12	4	3	1	0	5	0	.095
May	72.0	51.9	62.0	95	1887	27	1876	3.20	2.96	1889	T.	0.9	1923	72	55	50	257	57	10.2	nw.	53	nw.	1914	9	11	11	13	0	6	0	1	0	0	.083
June	80.1	60.5	70.3	99	1895	39	1879	3.67	3.19	1912	0	0	0	74	55	62	285	63	9.5	nw.	51	nw.	1917	7	14	9	12	0	8	1	8	0	0	.093
July	84.1	64.8	74.4	103	1881	48	1894	4.13	3.85	1887	0	0	0	75	54	60	297	65	8.9	nw.	48	nw.	1919	9	15	7	12	0	9	1	8	0	0	.109
August	82.0	62.9	72.4	103	1918	45	1890	3.19	3.65	1888	0	0	0	78	56	61	262	61	8.7	nw.	44	nw.	1925	10	13	8	10	0	7	2	4	0	0	.128
September	78.5	57.3	66.9	102	1881	35	1879*	2.55	4.08	1876	0	T.	1895	80	57	63	231	62	9.0	nw.	46	n.	1917	10	12	8	10	0	4	3	1	0	0	.150
October	64.4	45.8	55.1	91	1884	20	1887	2.50	3.22	1929	0.2	3.0	1917	80	59	64	187	54	9.8	nw.	47	nw.	1913	10	10	11	10	1	1	6	0	1	0	.181
November	50.7	35.8	43.2	79	1878	1	1929	2.33	2.13	1926	1.8	14.0	1913	76	66	68	118	40	11.3	w.	43	nw.	1927	6	9	15	12	7	0	2	0	10	0	.182
December	41.1	27.3	34.2	73	1885	−9	1880	2.75	2.44	1901	6.4	10.7	1894	78	71	72	84	29	11.5	w.	54	w.	1909	4	9	18	14	12	0	2	0	21	0	.178
Year	61.8	43.9	52.8	103	Aug. 6 1918	−20	Feb. 10 1899	35.92	4.08	Sept. 17 1876	32.3	15.0	Mar. 5 1902	77	60	65	2294	50	10.6	nw.	56	w.	Jan. 19 1928	86	131	148	150	62	40	22	15	90	2	.140

*Also in 1893 and 1925 †Also Feb. 14, 1923. Wind is in True Velocity. Elevation of Barometer is 842 feet.

Fig. 2—Comparative weather data for Pittsburgh, Pa., as published at the end of 1933

Form No. 1150—Aw

U. S. DEPARTMENT OF AGRICULTURE, WEATHER BUREAU

MONTHLY SUMMARY OF TEMPERATURE AND DEW POINT

Station Pittsburgh Altitude 1250 Ft. Month July 1933 Time -32 min. after hour 75th meridian

DAY	1	2	3	4	5	6	7	8	9	10	11	NOON	1	2	3	4	5	6	7	8	9	10	11	MID'T	SUM OF DIF.	MEAN DIF.
1	76	74	73	74 68	72	73	74	76 46	79	82	84	86 71	90	88	78	73 67	72	72	72	74 70	75	74	73	71 68	44	7.3
2	70	70	69	69 68	68	68	69	71 63	75	78	79	76 71	71	72	74	73 70	73	73	68	68 67	68	68	67	64 62	15	2.5
3	63	60	59	58 56	57	57	57	58 54	59	60	62	63 53	65	68	69	69 49	71	71	69	67 50	65	64	62	61 52	62	10.3
4	59	58	58	56 53	55	55	58	63 50	66	69	71	72 52	75	75	76	77 50	77	76	76	77 54	72	69	66	65 56	92	15.3
5	63	61	60	59 53	59	58	61	66 52	69	72	74	76 55	77	77	80	80 52	79	79	77	73 53	71	69	68	67 53	103	17.2
6	65	66	66	64 51	60	58	63	68 53	71	74	76	78 53	80	82	83	83 56	83	82	82	77 56	74	73	72	71 55	114	19.0
7	67	66	65	63 55	62	62	64	70 60	75	79	81	84 63	85	86	87	87 60	86	86	83	79 58	76	75	74	73 56	102	17.0
8	72	69	67	66 58	65	65	65	70 61	75	79	83	86 63	88	84	83	71 59	74	70	72	72 66	71	71	71	71 67	69	11.5
9	71	71	71	70 65	70	70	71	73 66	75	78	80	78 66	78	80	83	85 55	84	82	81	77 52	74	72	70	69 55	92	15.3
10	67	66	65	64 55	64	63	63	67 53	72	77	79	80 50	78	81	82	80 49	81	81	80	76 49	72	71	70	70 51	128	20.8
11	66	65	63	62 50	61	60	63	68 52	72	75	76	78 50	79	80	83	82 51	83	82	81	76 49	72	72	69	69 54	130	21.7
12	68	69	67	62 53	62	61	63	68 56	71	74	76	76 53	79	81	80	81 52	80	79	77	74 50	71	70	68	67 52	112	18.7
13	66	64	63	62 55	62	61	63	67 55	68	72	75	76 54	76	78	77	81 54	79	76	75	72 50	69	67	65	64 54	100	16.7
14	64	62	62	59 54	58	59	61	65 51	69	73	75	79 50	79	80	82	80 54	81	78	76	73 51	70	69	68	66 54	108	18.0
15	65	63	62	60 58	63	62	64	68 60	70	74	76	80 62	83	83	88	74 65	68	66	67	66 68	66	66	67	64 60	47	7.8
16	63	63	63	62 59	62	62	62	64 62	67	71	77	77 47	76	83	87	69 63	68	69	69	66 62	65	64	63	62 60	30	5.0
17	62	62	60	59 58	59	60	62	64 56	68	70	71	73 59	74	76	76	78 49	78	77	76	72 54	70	69	66	67 53	94	15.7
18	65	62	62	60 49	57	58	62	65 55	70	76	77	78 53	76	78	79	80 58	80	81	78	74 61	70	69	69	68 56	93	15.5
19	67	66	65	64 57	64	63	66	70 60	76	79	81	82 55	84	85	84	85 55	87	84	82	78 56	76	75	74	73 57	112	18.7
20	70	69	67	67 61	67	67	67	72 59	78	83	84	86 52	87	89	89	91 55	87	87	85	83 60	81	78	76	76 60	126	21.0
21	72	76	70	68 65	68	67	69	74 65	78	81	85	89 60	91	92	92	93 57	92	91	89	86 60	85	82	80	80 60	125	20.8
22	77	77	75	75 61	73	72	73	78 66	82	86	88	93 61	89	94	94	72 62	75	79	78	76 65	76	75	75	75 63	93	15.5
23	74	72	72	71 65	76	69	71	76 67	81	84	88	92 70	94	95	96	96 68	96	95	89	85 66	83	81	79	78 65	99	16.5
24	77	76	77	78 65	74	72	73	76 67	78	80	83	86 49	88	88	88	82 70	70	71	72	71 70	71	70	70	70 68	54	9.0
25	69	68	68	67 66	67	67	67	68 67	69	72	72	73 68	74	76	76	76 67	76	75	72	71 67	70	69	68	68 65	23	3.8
26	67	67	66	65 62	65	64	65	65 59	65	66	66	66 60	67	65	63	63 63	63	65	65	65 63	65	64	64	64 62	19	3.2
27	64	63	63	63 62	63	64	64	66 63	70	74	78	75 63	78	79	79	79 64	79	77	76	74 65	73	72	70	68 63	48	8.0
28	67	66	66	66 62	64	64	66	71 65	75	77	78	79 65	83	85	86	86 64	86	85	82	78 66	77	75	73	72 66	65	10.8
29	71	69	68	67 65	67	68	71	74 67	76	80	82	82 74	81	85	85	87 72	87	87	84	81 68	79	78	76	75 70	52	8.7
30	75	75	73	72 68	73	73	74	75 69	74	77	82	84 70	86	88	89	87 67	85	88	85	82 70	81	80	80	79 70	66	11.0
31	79	77	76	75 68	74	74	75	78 72	81	84	85	87 69	90	90	92	92 70	91	89	86	84 68	82	80	79	78 71	78	15.0
Sums	2121	2081	2056	2039 1833	2097	1996	2046	2182 1883	2259	2353	2410	2472 1967	2503	2503	2519	2498 1982	2471	2453	2404	2334 1965	2270	2231	2192	2162 1866	2492	415.3
Means	68.4	67.1	66.3	65.9 59.3	67.7	64.4	66.0	70.4 60.7	72.7	75.9	78.1	79.7 60.6	80.7	80.7	81.2	80.5 59.5	79.7	79.1	77.5	75.5 60.0	73.3	72.0	70.7	69.7 60.2	80.4	13.4
Mean Difference				6.6				9.8				19.5				21.1				15.0				9.7	80.3	13.4

Fig. 3—Monthly dry-bulb and dew-point temperatures as assembled by the Aerological Division of the U. S. Weather Bureau

Thus only the noon readings of the Climate and Crop Weather Division are at uniform local time and of value in comparing cities in different parts of the country.

In addition to the monthly summary, each of the Climatological Stations issues an annual summary containing the monthly averages of the various factors for the year; this report also contains a summation of the monthly averages on each factor for all the years of record as shown in Fig. 2. Most of the stations have been taking records for a period of over 20 years, many of them for 50 years, hence these data are very valuable for checking to see whether a particular year has been an average year, or has gone towards either extreme on the various factors.

Since average values of one or two daily readings only are not satisfactory for the determination of proper design values in the heat exchange industry, very little basic data in readily usable form can be gleaned from the records available in the Climate and Crop Weather Division. The Aerological Division, while it does not publish the data collected, does take temperature readings at hourly intervals at its stations in the various airports throughout the country. The dry-bulb temperature and the wet-bulb temperature are read each hour, the dew-point is calculated from these readings, then the dry-bulb and the dew-point are recorded on a daily sheet, which data remain on file at the station. No monthly or other periodic summation is made of these readings, either for publication or department use. Luckily, however, there was a period of 5 years, from 1930 to 1934, inclusive, when a monthly summary sheet was made and a pencil copy forwarded to Washington. A section of such a form, with the readings inserted for Pittsburgh, is shown in Fig. 3, and cover the same month as in Fig. 1. From these data, the dry-bulb and dew-point temperatures may be analyzed hour by hour, also the wet-bulb temperatures can be calculated from these readings, thus enabling a count to be made of the number of times each temperature has occurred in a period at several individual hours of the day.

By arrangement with D. M. Little, in charge of the Aerological Division, photostatic copies were obtained of these monthly summaries from practically all of the stations for which they were on file, and for as many years as they were available. The year of 1932 was not available from any of the stations, as the records for that year had been bound in volumes from which it was impractical to attempt to obtain copies. The resulting mass of data for this study, therefore, included three or four years of records from 67 cities scattered as uniformly as possible over the United States. On all of the records, the readings of dew-point in the early years had been taken at four-hour intervals only, and in some

cases six hours, but in later years all records contained 24 readings per day.

Summation of Summer Temperature Data

The records containing six readings per day, or more, fitted nicely into the plans for developing weather data which were to be based on an analysis of conditions at four-hour intervals, each reading to be considered as representative of the two hours preceding and the two hours following. When the fact is considered that the Weather Bureau has found that the average of the daily maximum and minimum dry-bulb temperatures at any one station comes within less than a degree of the 24-hourly average, readings at four-hour intervals would permit summations as accurate for the purposes of this study as hourly readings.

The first step in the analysis consisted of counting the number of times each dry-bulb, wet-bulb and dew-point temperature occurred at each of the six daily readings each year at each station during the season of June, July, August and September. The dry-bulb and dew-point values could be taken directly from the forms, but to obtain each wet-bulb temperature it was necessary to convert back from the dry-bulb and dew-point temperatures to obtain each individual reading. The conversion of over 150,000 such pairs of readings was the largest single task of the entire project.

The data obtained were summed up for the entire period on each city, and accumulated in a uniform condensed form similar to that shown for the wet-bulb temperature of Kansas City in Table 1. Columns 2A, 2B, 2C, 2D, 2E and 2F show the actual number of times that the various temperatures occurred at the four-hour intervals. The total number of readings at each temperature in the four years is given in Column 3. It is obvious that the total number of readings on four-hour intervals in a four-year period is, when each reading is considered representative of a four-hour period, also the average number of hours per season. Thus Column 3 is both total readings and average number of hours per season. Columns 4A to 4F, inclusive, are the accumulative totals of the readings in Columns 2A to 2F, respectively, or are the number of readings in which the temperature shown was equalled or exceeded. The total Column 5 is the number of readings in the four seasons, or hours per normal season, and the final column the percentage of time that each temperature was equalled or exceeded.

Summations similar to this one were made of the dry-bulb, wet-bulb and dew-point temperatures for the

Table 1—Analysis of Wet-Bulb Temperatures, Kansas City, Mo.
Frequency of Occurrence During Season of
June to September, Inclusive, in Years 1930-1931-1933-1934

Wet-Bulb Temp. F	At Temperatures Shown Number of Readings at Time Indicated							At or Above Temperatures Shown Number of Readings at Time Indicated							
	A. M.			P. M.			Total Hours per Season	A. M.			P. M.			Total Hours per Season	Per Cent At Or Above
	3	7	11	3	7	11		3	7	11	3	7	11		
79	.....	.....	.....	6	6	.....	12	.....	.....	.....	6	6	.....	12	0.4
78	.....	.....	4	5	3	2	14	.....	.....	4	11	9	2	26	0.9
77	.....	.....	5	12	7	2	26	.....	.....	9	23	16	4	52	1.8
76	1	1	8	19	11	9	49	1	1	17	42	27	13	101	3.4
75	2	5	30	35	29	15	116	3	6	47	77	56	28	217	7.4
74	8	6	23	32	29	21	119	11	12	70	109	85	49	336	11.5
73	20	16	49	43	46	29	203	31	28	119	152	131	78	539	18.4
72	19	24	41	45	43	34	206	50	52	160	197	174	112	745	25.4
71	37	29	41	46	51	36	240	87	81	201	243	225	148	985	33.6
70	38	28	42	39	37	58	242	125	109	243	282	262	206	1227	41.8
69	45	34	24	21	26	43	193	170	143	267	303	288	249	1420	48.5
68	41	46	33	25	29	26	200	211	189	300	328	317	275	1620	55.3
67	32	41	21	18	20	26	158	243	230	321	346	337	301	1778	60.7
66	22	28	12	18	22	30	132	265	258	333	364	359	331	1910	65.3
65	25	23	23	21	21	20	133	290	281	356	385	380	351	2043	69.7
64	23	20	26	19	19	16	123	313	301	382	404	399	367	2166	74.0
63	24	31	15	17	17	16	120	337	332	397	421	416	383	2286	78.1
62	19	27	13	15	10	14	98	356	359	410	436	426	397	2384	81.4
61	14	21	12	6	13	19	85	370	380	422	442	439	416	2469	84.3
60	12	7	15	10	7	9	60	382	387	437	452	446	425	2529	86.4
59	28	14	9	5	6	15	77	410	401	446	457	452	440	2606	89.1
58	10	15	9	8	8	6	56	420	416	455	465	460	446	2662	91.0
57	9	11	7	5	5	5	42	429	427	462	470	465	451	2704	92.4
56	9	5	4	2	6	5	31	438	432	466	472	471	456	2735	93.4
55	7	10	4	5	4	5	35	445	442	470	477	475	461	2770	94.6
54	7	9	2	3	6	6	33	452	451	472	480	481	467	2803	95.8
53	7	8	1	3	1	6	26	459	459	473	483	482	473	2829	96.7
52	3	6	4	2	2	7	24	462	465	477	485	484	480	2853	97.3
51	10	5	5	1	1	1	23	472	470	482	486	485	481	2876	98.3
50	.....	1	4	.....	.....	2	7	472	471	486	486	485	483	2883	98.6
49	2	5	.....	.....	.....	1	8	474	476	486	486	485	484	2891	98.8
48	8	1	.....	1	1	3	14	482	477	486	487	486	487	2905	99.2
47	2	1	.....	.....	.....	.....	3	484	478	486	487	486	487	2908	99.4
46	2	2	1	1	.....	.....	6	486	480	487	488	486	487	2914	99.5
45	1	3	.....	.....	2	.....	6	487	483	487	.....	488	487	2920	99.7
44	.....	2	.....	.....	.....	.....	2	487	485	487	.....	.....	487	2922	99.8
43	.....	1	1	.....	.....	.....	2	487	486	488	.....	.....	487	2924	99.8
42	.....	.....	.....	.....	.....	.....	.....	487	486	.....	.....	.....	487	2924	99.8
41	.....	1	.....	.....	.....	1	2	487	487	.....	.....	.....	488	2926	99.9
40	1	.....	.....	.....	.....	.....	1	488	487	.....	.....	.....	.....	2927	99.9
39	.....	.....	.....	.....	.....	.....	.....	.....	487	.....	.....	.....	.....	2927	99.9
38	.....	1	.....	.....	.....	.....	1	.....	488	.....	.....	.....	.....	2928	100.0
Avg Temp F	64.7	64.4	67.8	69.0	68.5	67.0	66.9	.....	.....	.....	.....	.....	.....	.....	.....
Col. No. 1	2A	2B	2C	2D	2E	2F	3	4A	4B	4C	4D	4E	4F	5	6

NOTE: These data taken from Form No. 1140 of the Aerological Weather Station at Kansas City, Mo. Airport.

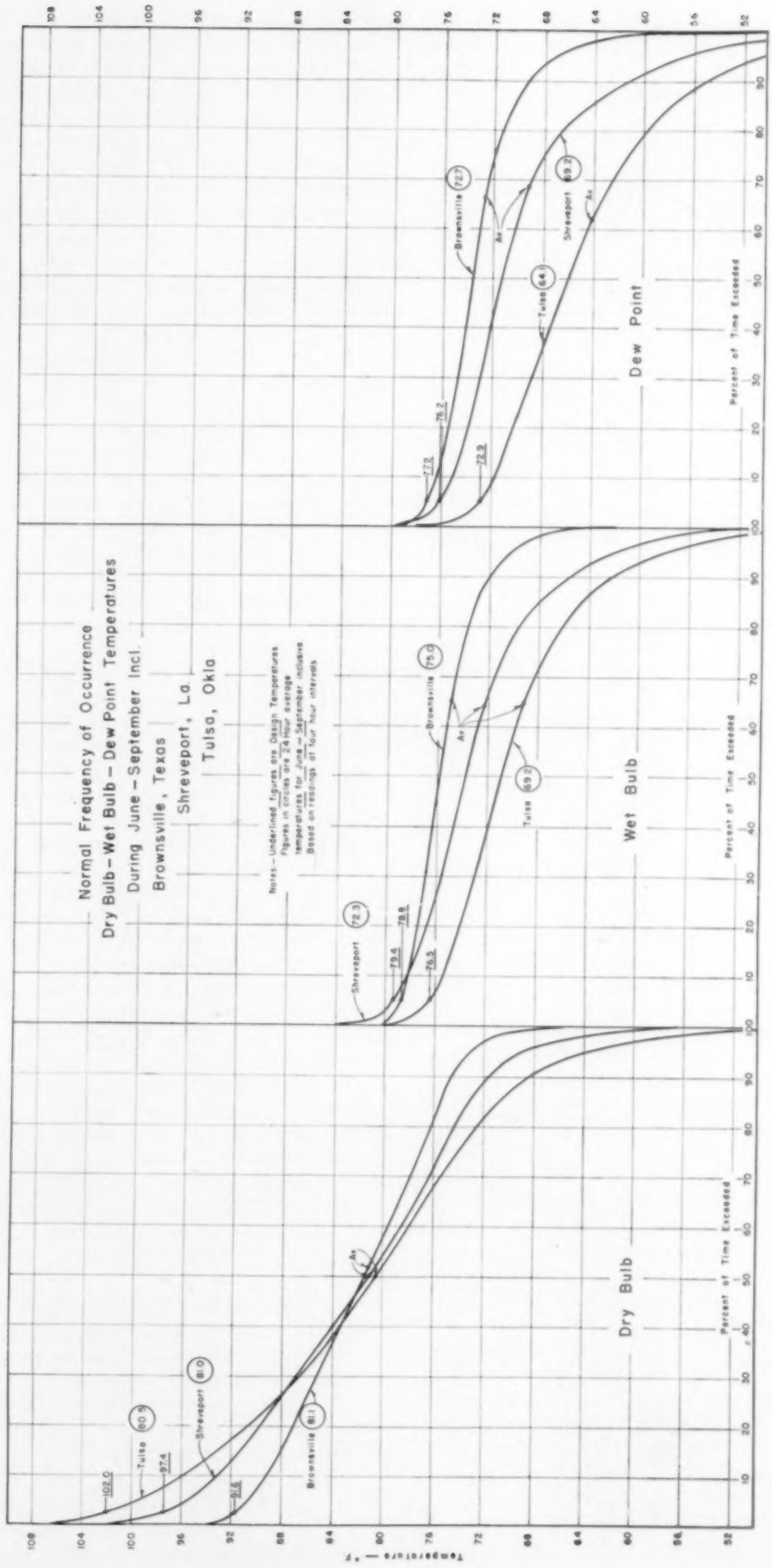

Fig. 4—Comparative seasonal temperatures at representative locations

entire group of 67 cities. To amplify further the knowledge of the variations of these factors throughout the United States, and to check with the data from the Aerological Section, the average monthly noon dry-bulb, wet-bulb and dew-point temperatures for 1930 to 1934, inclusive, as taken at the Climatological Stations, were obtained for the 200 available locations, along with the averages of the morning and evening observations from the Climatological Stations for the 67 cities from which the Aerological data were taken. Comparison between the averages of readings taken simultaneously at Climatological and Aerological Stations in the same cities showed normal agreements within tenths of degrees.

Study of Comparative Characteristics

Temperatures do not remain fixed for even a short period of time, but are continually changing, both daily and seasonally, these variations having entirely different values and rates of change in different parts of the country. Since the equipment designed upon the basis of these accumulated data must have sufficient capacity to meet, with reasonable results, the normal maximum temperatures at the location, and flexibility enough to meet both the daily variation and the total range of the season, these characteristics deserve close study.

The total amount of the seasonal variation is obvious from an inspection of each summary sheet. The character of the distribution of the readings over this range is of more importance and can be observed most readily from a graph of the percentage of time that each of the readings is exceeded, as shown in Fig. 4. Lying on approximately the same meridian, in the middle of the western plains, far from large mountain ranges or other disturbing topography, the data from Brownsville, Tex., Shreveport, La., and Tulsa, Okla., afford an excellent basis for comparative study.

From the left-hand chart it will be noted that the three cities have approximately the same average dry-bulb temperature. This average was obtained by summing up all readings taken during the entire period of analysis and dividing by the number of readings, thus giving a true weighted average—(see averages at bottoms of Columns 2A to 3 in Table 1). It happens that the average temperature in each case is exceeded approximately 50 per cent of the time, a condition which does not always obtain. Yet it will be noted that the slope of the Tulsa curve is much steeper than that of Shreveport, which in turn exceeds that of Brownsville, the flatter slope of the southern cities being due to the blanketing effect of more water vapor in their atmosphere than in that of the northern locations. Obviously, the average temperature is not a satisfactory basis for design, and, in view of the readings, neither could a common number of degrees above the average temperature added to that average give a reasonable result. For instance, if a value were taken of 94 F, which is the maximum temperature noted for Brownsville, that value would be exceeded 7.5 per cent of the time in Shreveport, or 220 hours per season, and 381 hours in Tulsa, which is 13 per cent of the time. The use of the maximum temperature read in Brownsville in design would result in the specifying of equipment that would be operating at less than its rated capacity for the entire season in Brownsville; would possibly be satisfactory in Shreveport, where fly wheel action might carry the installation through the peaks that exceed that temperature; and would be found short of its requirements in Tulsa for such long periods at a time as to be entirely unsatisfactory. Obviously, a higher dry-bulb design basis must be used in Tulsa than in Shreveport, and Brownsville should be the lowest of the three. Perhaps it will be surprising to find that the Gulf Coast cities, even though they require the lower design dry-bulb temperatures, have, in general, higher average dry-bulb temperatures than more northern midwest locations. This apparently inverted condition, caused by the continuous decline in moisture content of the atmosphere from south to north, persists to a peak in central Kansas, and from that point north is reversed, and the dry-bulb design temperatures fall as normal judgment would dictate they should.

A similar investigation of the wet-bulb and dew-point temperatures reveals that on both of these factors the Tulsa record shows expectancy of lower temperatures at all times than at the other two locations. Shreveport, while normally having a lower wet-bulb temperature than Brownsville, has higher top readings and a greater number of readings at these top temperatures, hence Shreveport should have equipment designed to meet a higher wet-bulb temperature than Brownsville. On dew-point, the character of the curves is such that Brownsville must obviously have a higher dew-point design temperature than Shreveport. Note that the averages of all three locations are exceeded between 60 and 70 per cent of the time on both the wet-bulb and dew-point curves. Reasons for the average being not at the 50 per cent point are readily discernible from the shape of the curves, which are much flatter above the average point than below, thus showing that the maximum is fewer degrees above the average than the minimum is below it.

These seasonal time-temperature graphs, while similar in general contour throughout the country, vary greatly in the slope of the center portion of the curve, and in the percentage at which the ends begin to curve rapidly. The total range and slope of the graph varies from a minimum in Florida and Southern California, to a maximum in the central Rocky Mountain District, the values increasing along each coast from south to north, with those on the East Coast increasing more swiftly than on the West. Mid-continent curves are steeper than those on either coast at the same latitude. The widest dry-bulb and wet-bulb ranges are in Nevada. Arizona, notoriously arid, shows the greatest seasonal dew-point differential. These rather orderly variations in seasonal variations are an inverse function of the dew-point temperature, which fact *is of major importance in the determination of proper design temperature values.*

The daily variation to be expected is of perhaps even more importance in the design of heat exchange equipment than the anticipated seasonal range. Characteristic daily variations for a number of different cities on the dry-bulb, wet-bulb and dew-point temperatures are shown in Fig. 5. Since, from the previous discussion of Fig. 4, it is obvious that designers can make little use of average temperatures, but must base their work on some temperature nearer the maximum, this series of graphs show the temperatures which will be exceeded not more than six times per year. These six occasions

did not, of course, all occur on the same six days, but the curves simply mean that the temperatures shown at 6 A. M. and 6 P. M. each would be exceeded six times in a normal year, although none of the high readings at 6 P. M. necessarily took place on the same day that a high reading was experienced at 6 A. M.

From repeated comparisons it was found that the shape of these curves checks directly with the shape of the weighted average temperature curves plotted for the various hours of the entire day; also that the seasonal range at any one hour is approximately equal to that of any other hour of the day. Such difference in range as exists at different hours tends to show a slightly greater seasonal variation in the afternoon dry-bulb than in the period just before dawn, but the exact reverse is true on the wet-bulb temperature, while the dew-point has no uniform trend.

The daily march of the dry-bulb follows the expected path, in that the temperature slides downward in a smooth curve throughout the night, reaching a minimum just about sunrise, turns rather abruptly upward and rises at a rapid rate that slows down as the day progresses, coming to a peak in the afternoon, and reversing the morning curve as it drops off. The evening cooling is not as rapid as the morning heating, and the curve slows down in its rate of drop from sundown until the minimum is reached the next morning.

Note that Seattle, Wash., despite a lower average dry-bulb temperature, should have a design dry-bulb value well above that for Laguna Beach, Calif., also that Wichita, Kan., with approximately the same average dry-bulb temperature as Miami, Fla., justifies on this graph a design value 13.5 F higher than Miami, whereas New York should have the same design basis as Miami, although its average dry-bulb temperature is 7.3 F lower. Similar inverted evidence is the rule rather than the exception throughout the country, again the direct result of relative moisture content in the atmosphere.

Other things being equal, the greater the amount of water vapor in the air, the smaller will be the daily and seasonal range of dry-bulb temperatures. One reason for this is that the water vapor in the air reduces both the radiant energy of the sun reaching the earth's surface during the day and also the radiation to outer space at night. An important factor in controlling dry-bulb temperature at the surface is evaporation which process

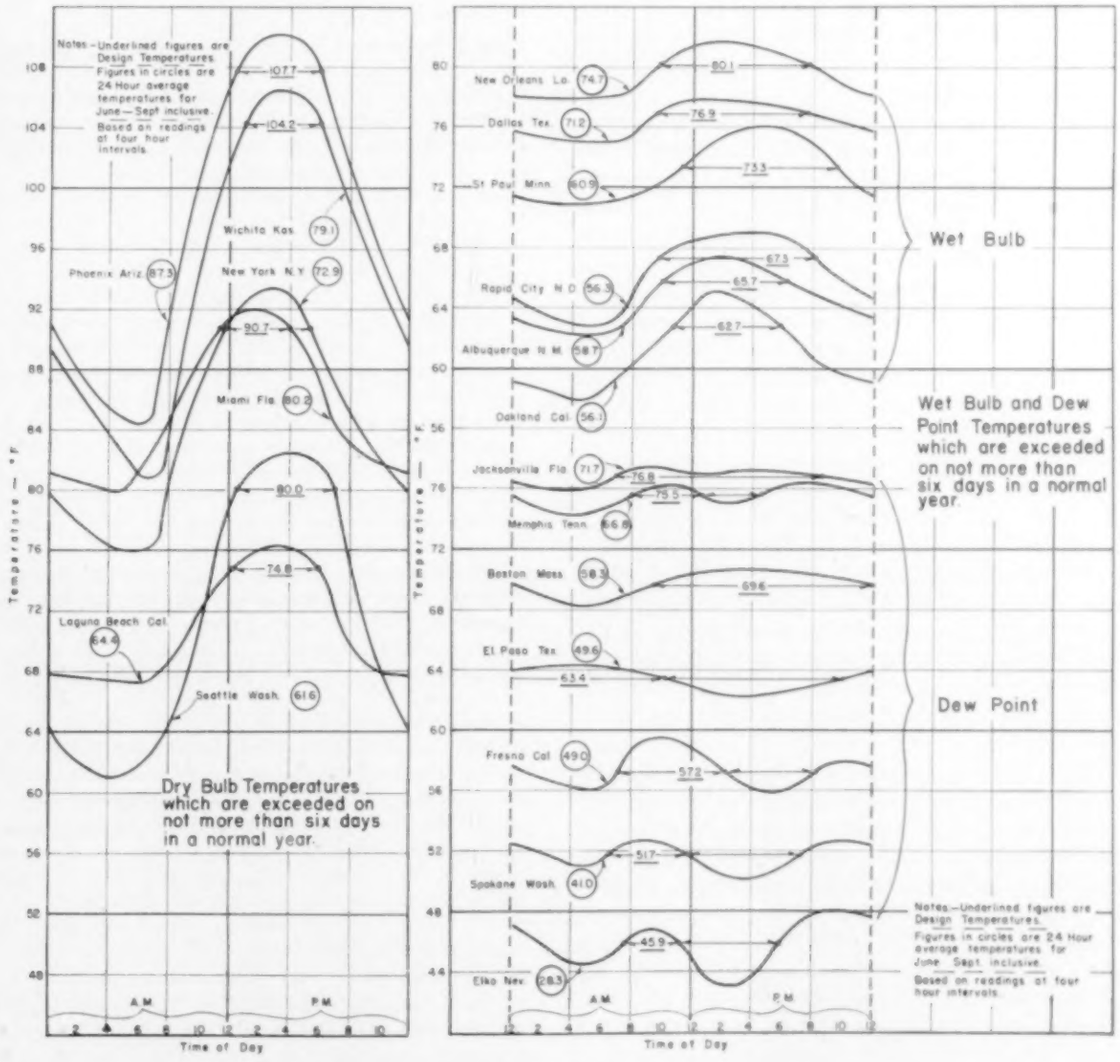

Fig. 5—Comparative daily temperature characteristics

absorbs sensible heat, and thus tends to hold the maximum daily surface temperature down. At the minimum temperatures, more dew is deposited in the areas having the higher water content in the atmosphere, and the condensing of this water vapor releases latent heat, thus tending to keep the minimum temperatures higher. These facts combine to account for the relatively small daily temperature ranges at locations having a normally high dew-point temperature. Most important, however, the reduction in dry-bulb temperature which normally accompanies an increase in dew-point temperature *precludes the probability of extreme dry-bulb temperatures occurring simultaneously with extremes in dew-point or wet-bulb temperature.*

The conductivity and specific heat, or heat absorbing capacity of the terrain, likewise affects the daily temperature variation. A damp surface has greater heat absorbing power than a dry one. Cultivated ground absorbs more heat than a sandy desert. The higher the absorbing qualities, the smaller is the daily swing in temperatures. The direction, velocity and source of the wind is a major factor in the daily temperature variation. For instance, air coming from warm areas and passing over heated plains increases in temperature and adds to the natural sun effect on the ultimate areas reached. The increase in number of hours of sunshine per day from South to North in the summer season tends to increase the differential between night and day time temperatures in the Northern locations.

There is less water vapor present on the average at elevated locations than near sea level hence there is less blanketing of solar radiation by water vapor in the air, and conversely, there is a large radiation to outer space at night, with the result that both the seasonal and daily ranges increase with elevation. Mountainous regions are subject to great mechanical turbulence in air movement, and as high wind velocities accelerate the rate of moisture evaporation from the surface and rapidly dissipate the moisture so evaporated, the tendency is to large temperature variations in such districts. Convection air currents are partially responsible for the extreme daily ranges noted in mountain valleys.

The wet-bulb temperature curves follow those of the dry-bulb temperature in general contour, but are not as smooth and the range is much smaller. The afternoon peak may be reached either before or after the dry-bulb peak and the crowns of these peaks are flatter. On individual days, the wet-bulb temperature may rise steadily throughout the day into the night, so that high wet-bulb temperature readings are frequently observed at night, whereas high dry-bulb temperature readings at night are very rare.

Logical design values for various locations frequently are inverted from the evidence of the average wet-bulb temperatures, for reasons similar to those already found to be the case in the dry-bulb temperatures. Albuquerque, with the higher average wet-bulb temperature, requires a lower design value than Rapid City, N. D. Oakland, Calif. (San Francisco), has a 5.1 F lower design value than Rapid City, although it has approximately the same average wet-bulb temperature. The magnitude of the daily range is not accompanied by a proportional seasonal range, as may be noted by comparing Oakland and Rapid City, which reverse on these two items.

The dew-point temperature is the surprising factor, following daily cycles that at first glance appear illogical. In most inland cities, a valley occurs in the dew-point graph during the afternoon, when the dry-bulb and wet-bulb temperatures normally reach their peaks. Climbing back to a peak in the evening, the dew-point begins to drop in the late evening, reaching a second valley coincidentally with the valleys of the dry-bulb and wet-bulb in the early morning, rising to a peak before noon, then sliding rapidly down to the afternoon valley. Thus the characteristic dew-point graph shows a daily double cycle for most of the locations in the country. In seaboard cities the afternoon valley may disappear or be present to a minor degree. In the Western plains and mountains, the morning valley is frequently washed out, in some cases the peak of the day occurring simultaneously with the minimum dry bulb. Combinations of topographical features can give almost any single or double cycle characteristic daily curve for the dew-point temperature. L. P. Harrison, Meteorologist of the U. S. Weather Bureau comments on the behavior of the dew point as follows:

"As is well known, the diurnal march of vapor pressure at the surface generally shows a regular periodic variation. Inland regions in summer show two maxima and two minima, occurring at about 6 to 9 A. M. and 8 to 9 P. M., for the former, and 3 to 4 P. M. and 3 to 4 A. M., for the latter. In general, the oceans in summer and winter and most inland regions in winter show but one maximum and one minimum, similar to the diurnal march of the dry-bulb temperature, the maximum occurring during the afternoon and the minimum during the early morning. Coastal stations show variations between the extremes outlined above, but resemble the oceans most closely.

"The causes of this diurnal march of absolute humidity at the surface are substantially as follows: In *summer,* at *inland* stations, the ground at dawn is greatly cooled due to the nocturnal radiation, especially so if the night has been clear. The subsidence of the air during the night due to this cooling and to the relative absence of convection carries much moisture down to the ground layers from the atmosphere. These two processes conduce to the process of condensation near the ground, and the formation of dew, especially if vegetation is present. Hence the low temperatures near the ground cause the space to have a smaller capacity for water vapor and also cause the removal under proper circumstances of much of the water vapor by condensation, producing a minimum of vapor pressure and absolute humidity near the ground just before dawn. This is the so-called *secondary minimum.*

"As the sun rises, it warms the ground and evaporates much moisture. The lapse rates at first are insufficient to cause much instability, hence the vapor pressure rises to the *primary maximum* occurring between 6 and 9 A. M. When the sun gets higher, convection becomes active, carrying much water vapor away from the ground layers. By the time the afternoon maximum temperature (dry-bulb) has been reached, the supply of surface ground water has been greatly depleted and the rate of evaporation from the ground has become less than the rate at which the ascending air currents and eddies carry the moisture aloft. Hence we have the *primary minimum* of vapor pressure (and absolute humidity) at the surface occurring about mid-afternoon in the summer at inland stations. The evening (*secondary*) *maximum* occurs as a result of the rapid subsidence of air at dusk or shortly thereafter when convection has greatly diminished, and also as a result of the comparatively small decline in temperature (dry-bulb) near the ground."

The characteristics of the curves in Fig. 5 check closely with Mr. Harrison's comments, although in some cases the evening peak is found at a later hour and occasionally there is no downward drop during the night.

A representative example of this latter case may be noted in Fig. 6, on which the dry-bulb, wet-bulb and dew-point temperatures for each hour of the period of July 12 through July 16, 1934, for Dallas, Tex., have been plotted, and a smooth line run through the respective readings. The dry-bulb shows a very uniform daily cycle, reaching its peak in each day about 4 P. M. In general, the wet-bulb curve reaches its peaks and valleys ahead of the dry-bulb temperature, but has the same typical appearance. The dew-point, on the other hand, generally reaches its one daily peak around 8 o'clock in the morning, and its valley from 4 to 8 in the afternoon. Of greatest interest, however, is to observe, through the five days of record at Dallas just cited, a consistent climb of the daily peak dry-bulb temperatures, accompanying a steady daily decline of the dew-point and wet-bulb temperatures, showing once more the blanketing effect of increased moisture content of the air. While Dallas is somewhat unusual in failing to show a morning valley, occur simultaneously; and that extreme dry-bulb temperatures *do not occur simultaneously* with either maximum dew-point or wet-bulb temperatures.

Design Temperatures

To meet the seasonal range, it is necessary that the equipment chosen be capable of operation with proper efficiency at the various daily loads. The daily temperature range and the speed with which changes take place call for the installation of control sensitive enough and equipment properly built to react to such control so that the daily variations are followed properly. The diversity between long ranges in one factor, combined with relatively short ranges in another, affects the choice of types of units to make up the entire system. Above all, however, the gross size of the equipment installed depends upon the outside operating temperatures assumed in the original calculations of the load.

Neither the average nor the maximum temperature is a satisfactory value on which to base a design. The

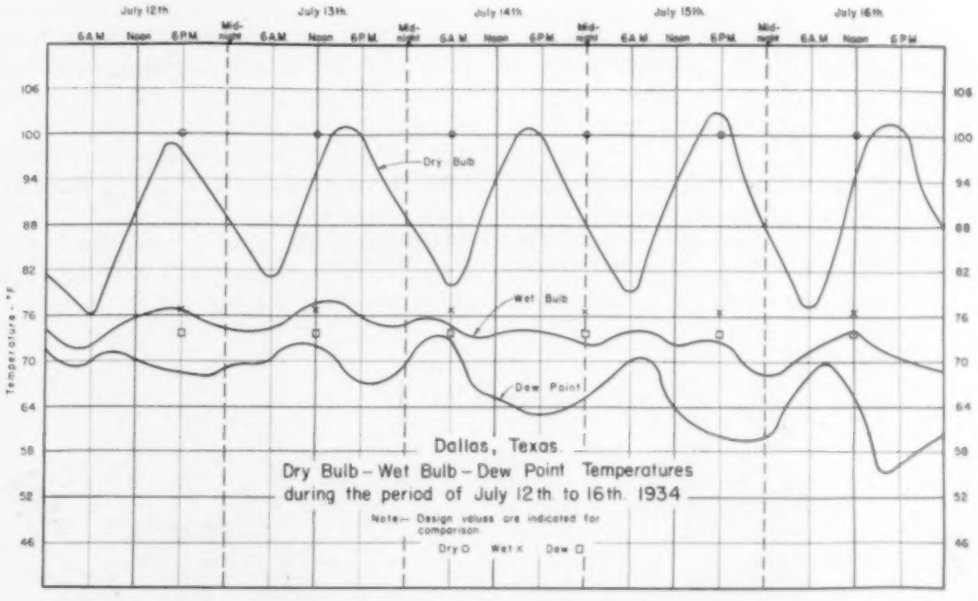

Fig. 6—Typical temperatures at Dallas, Texas

the important characteristic common to most stations of a minimum dew-point during the afternoon is decidedly evident. Note also that the behavior of the dew-point, as illustrated in Fig. 6, is responsible for the peak of the Dallas wet-bulb temperature on Fig. 5 being reached before noon, with a gradual drop taking place during the afternoon period, during which time many other locations experience their peak wet-bulb temperature.

Summing up the tendencies observed in the seasonal and daily curves, referred to previously, several major facts are obvious. Of these, the more important are: that the maximum daily temperature is attained as a rule for only a short time daily; that either the average or the maximum temperature is a poor basis upon which to build a judgment of a proper design value; that the seasonal and daily ranges vary through wide limits in different locations; that a wide variation in one factor may be accompanied by a relatively small one in another; that the maximum values of the three temperatures do not

former results in equipment of insufficient capacity to meet the load for over 50 per cent of the time. The latter would result in equipment which would never be loaded to capacity. The maximum value of any one factor does not exist simultaneously with extreme values in the other variables which also enter into the design calculation. Some compromise between maxima and average is the logical answer. An analysis of practice in various parts of the country indicates that installations based upon wet-bulb temperatures which are exceeded no more than 5 per cent of a normal season have given satisfactory results, without raising the first cost of the equipment too high. For instance, common practice in New York has been to use a 75 F wet-bulb as a design temperature, which, from the analysis, is found to be equalled or exceeded just 5 per cent of the normal season.

The hours that the wet-bulb temperature exceeds the 5 per cent value are, since close to the maxima, not

consecutive hours, but occur in periods of relatively short duration, and with dry-bulb temperatures well below the maximum. The fly wheel action of the system is usually sufficient to carry over such a condition. Discomfort can be endured or production curtailed for a short time without experiencing a financial loss that would dictate additional expenditure to meet the extreme conditions with perfect results. Reference to Figs. 5 and 6 substantiates this statement regarding the short duration of peaks.

The dry-bulb and wet-bulb temperatures are not the only factors that do not reach their maxima simultaneously with other values. For instance, the maximum dry-bulb temperature occurs after the peak of solar radiation has passed. The maximum dew-point may be experienced coincidentally with high wet-bulb temperatures, but it cannot exist simultaneously with the maximum dry-bulb temperature. While the maximum daily normal wind velocities occur in mid-afternoon, extraordinarily high wind pressures causing excessive infiltration of outside air are not experienced during high dry-bulb temperature periods. An analysis of Central Park Records shows that the dry-bulb and wet-bulb temperatures in New York reach or exceed their respective design values, which are well below the maxima, simultaneously only 37 hours in the normal year, scattered over eight different periods.

Considering the successful use of such values in past practice, the map shown in Fig. 7 has been developed to show the wet-bulb temperatures which are exceeded but 5 per cent of the time during a normal season. Similarly, Fig. 8 shows a map of dew-point temperatures which will be exceeded 5 per cent of the time during a normal season. The majority of the readings exceeding the wet-bulb values on the map occur during the 12 hours in the middle of the day. A much smaller portion of the excessive dew-point values occurs during that period, as was brought out in the discussion of Figs. 5 and 6. In fact, most of the high dew-point readings occur before 10 A. M. or after 7 P. M. Therefore, if a value of 5 per cent is satisfactory for a wet-bulb temperature design basis, certainly the same percentage is amply satisfactory on the non-coincidental dew-point temperature.

The peak dry-bulb temperatures all occur in the 12-hour span of the middle of the day. These points, combined with the fact that the daily range in dry-bulb temperature is much greater than either of the other two factors, dictate that the basis of choice of a dry-bulb temperature for use in design should be one that is exceeded a smaller percentage of the total time, or perhaps the same percentage of the daytime hours only. A choice of the correct dry-bulb temperature as that temperature which is exceeded but 5 per cent of the 12 hours of the middle of the day is a logical conclusion. Since all of the higher dry-bulb temperatures in the 24 hours occur during these hours, this is equivalent to saying that a satisfactory dry-bulb temperature is one exceeded no more than 2½ per cent of the hours in a normal season. The map in Fig. 9 is predicated upon the temperatures shown being exceeded no more than 2½ per cent of the time in a normal season.

Since high wet-bulb, dew-point and dry-bulb values do not occur simultaneously, it is logical that a coincidental dew-point calculated from the map values of dry-

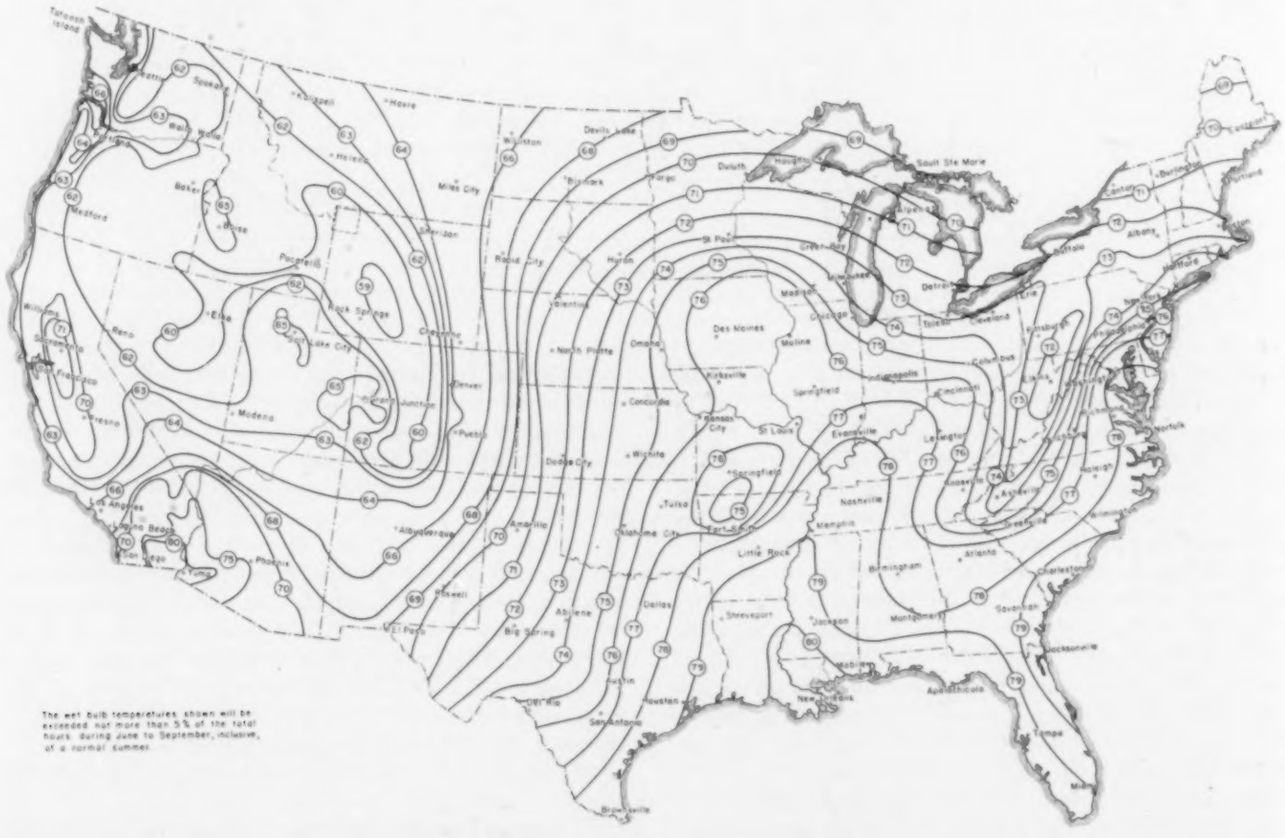
The wet bulb temperatures shown will be exceeded not more than 5% of the total hours during June to September, inclusive, of a normal summer.

Fig. 7—Summer wet-bulb temperature data

bulb temperature and wet-bulb temperature will be much lower than the map dew-point value. Similarly, the coincidental dry-bulb temperature calculated from the value of dew-point and wet-bulb temperatures taken from the maps would be much lower than the dry-bulb temperature shown. Simultaneous use, therefore, cannot be made of the three map values in design, but they must be used in pairs in those parts of the design where the pair chosen have more effect than the third factor. In many problems a value in design is dependent on only one of these variables.

In some few special cases, design values approximating the peak temperature to be expected in one factor in a normal year must be used, in which case the values from Table 2 may be used as reasonably safe maxima. These are not the maximum readings known at each station, as, for instance, the normal maximum wet-bulb temperature in New York is 81 F, yet a perfectly authentic reading of 88 F was recorded at 3 P. M. on July 28, 1931. This was a freak reading, lasting only a few moments, then dropping back below 80 F. Most exceptionally high readings in any of the variables are due to freak and abnormal conditions, and since sound engineering judgment would dictate ignoring such data, the table disregards values not normally reached each year.

When a combination of freakish weather circumstances occurs, an abnormal day will result, upsetting all expectancy, the effect of which cannot be counteracted in economical design, but must simply be endured because it is too expensive to do otherwise. For instance, on two occasions only during the period of 1925 to 1938, inclusive, the wet-bulb temperature at the Central Park Station of the City of New York reached and maintained an average reading of 80 F or more for a period of over seven consecutive hours. These took place on August 1, 1933, and July 9, 1936, and a graph of the wet-bulb and dry-bulb temperatures for these days is shown on Fig. 10. Later, in the same month of July, 1933, for the five days from the 20th to the 24th, inclusive, the wet-bulb remained steadily between the limits of 70 and 78 F during 8 A. M. to 5 P. M. each day. It is logical to design equipment to carry through the latter condition, but it is not warranted to meet in design the former condition, inasmuch as it occurred but twice in 14 years.

Throughout this paper a great deal of discussion has referred to the *normal* year, or the *normal* day. Actually, there is no such thing as a normal day, week, month or year in weather data, as the only thing consistent throughout about the weather is its inconsistency. Conditions in each of the factors are changing continuously, and the permutations are so great that for the conditions to duplicate any predicted combination over an appreciable period of time would be beyond the probabilities. One variable alone may follow the expectancy exactly, but it is beyond reason to expect all of them to do so simultaneously.

Influence of Geophysicial Features on Temperatures

In each of the three maps (Figs. 7, 8 and 9) may be noted, reflected on a broad scale, the effect of the geophysical characteristics which have been touched upon

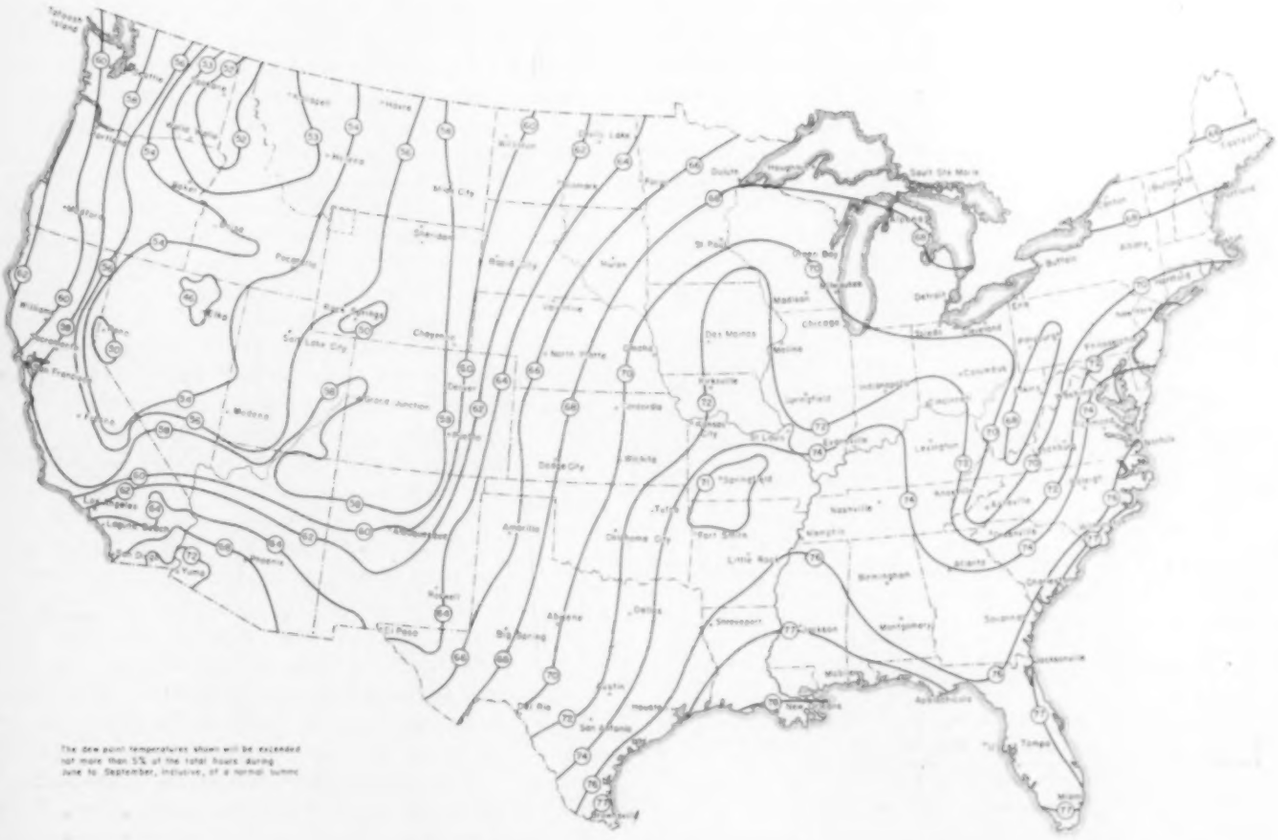
The dew point temperatures shown will be exceeded not more than 5% of the total hours during June to September, inclusive, of a normal summ

Fig. 8—Summer dew-point temperature data

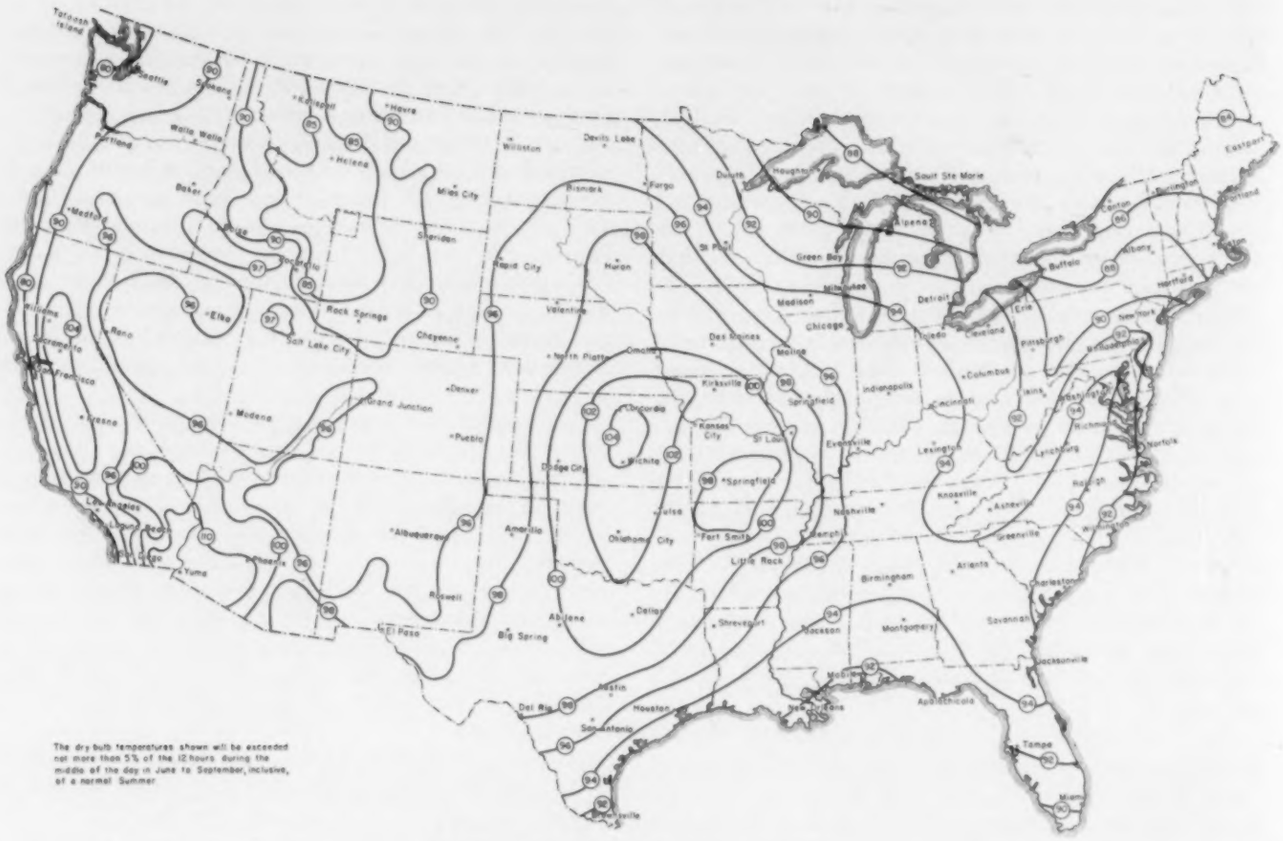
The dry-bulb temperatures shown will be exceeded not more than 5% of the 12 hours during the middle of the day in June to September, inclusive, of a normal Summer

Fig. 9—Summer dry-bulb temperature data

at various points throughout the discussion. The wet-bulb and dew-point values near the sea coast are higher, and the dry-bulb temperatures lower, due to the influence of the ocean, which decidedly affects both the moisture and sensible heat content of the air. The general effect of elevation may be seen in the downward dips of all temperature lines around the Eastern mountain barrier; by the steady fall of all temperatures between the Mississippi Valley and the Rocky Mountains; and even the relatively small elevated plateau of the Ozarks in Missouri and Arkansas reflects in reduced values compared to surrounding territory. In this latter case there seems to be a shielding effect on the land to the northwest, possibly due to the fact that prevailing winds to these regions pass over the Ozarks en route, as is evidenced by the bulges in the wet-bulb and dew-point lines around Kansas City. From the Rocky Mountains east to the coast, the variations in elevation are gradual enough to depend upon values interpolated between adjacent temperature lines, but west of a north and south line drawn through the eastern border of New Mexico, the country is so broken that the temperature lines can be taken only as a general indicator of conditions. To be accurate and thorough, every mountain and valley should be enclosed by a series of closed isothermals, with the minimum temperatures at the peaks of the mountains and the maximum at the center of the valleys. Certain major conformations reflect on all the maps, as the high ridge from Montana down through Wyoming to Colorado; the coast range in Western California; and the low areas in Central Washington, Central California, the Colorado River Valley and Great Salt Lake. The Climatological and the Aerological stations are normally located at cities and cities are built in valleys, therefore, the map values in broken country are for valley conditions. To determine completely temperature expectancy in mountainous country would require data from several times as many stations in such country as are needed for the same area in

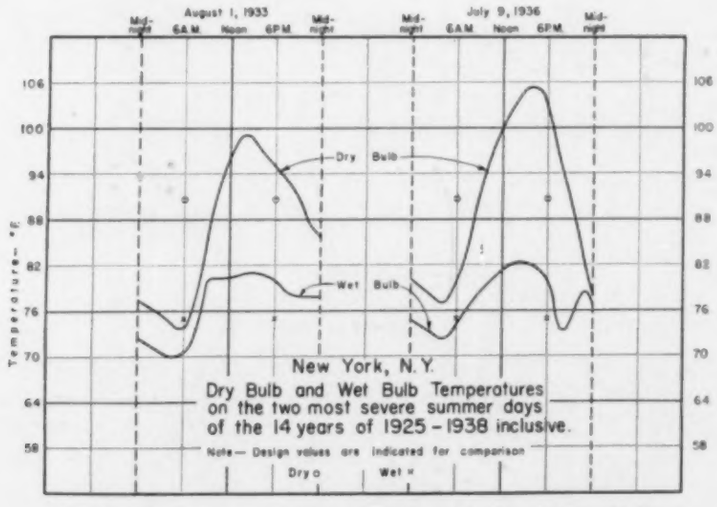

Fig. 10—Extreme temperature conditions in New York, N. Y.

Table 2—Reasonable Maximum Temperatures and Absolute Maximum Wind Velocities in the United States

State	City	Reasonable Maxima, Temp. F			Maximum Recorded Wind Velocity MPH
		Dry-Bulb	Wet-Bulb	Dew-Point	
Alabama	Mobile	95	82	80	87
Arizona	Phoenix	113	78	74	40
Arkansas	Little Rock	103	83	78	49
California	Fresno	110	75	66	41
	Laguna Beach	82	70	68	
	Oakland	94	68	67	50
	San Diego	88	74	72	43
	Williams	110	80	71	
Colorado	Denver	99	68	64	53
	Grand Junction	102	68	63	
Connecticut	Hartford		82		58
D. C.	Washington	99	84	80	55
Florida	Jacksonville	99	82	79	58
	Miami	92	81	79	87
Georgia	Atlanta	101	82	79	51
Idaho	Boise	109	71	65	43
Illinois	Chicago	104	80	77	65
	Moline	103	83	80	
Indiana	Evansville	102	82	79	60
Kansas	Wichita	110	79	74	68
Louisiana	New Orleans	95	83	81	66
	Shreveport	102	83	79	50
Massachusetts	Boston	96	78	76	60
Michigan	Detroit	101	79	76	67
Minnesota	St. Paul	103	79	75	78
Mississippi	Jackson	103	82	80	49
Missouri	Kansas City	109	79	76	57
	Kirksville	108	82	79	
	St. Louis	108	81	76	91
	Springfield	98	79	76	52
Montana	Helena	97	70	60	54
Nebraska	North Platte	104	76	71	73
	Omaha	108	80	75	53
Nevada	Elko	101	64	58	
	Reno	102	66	56	46
New Jersey	Camden	102	82	78	68
	Newark	99	81	77	
New Mexico	Albuquerque	98	68	66	63
New York	Albany	97	78	75	59
	Buffalo	93	77	74	73
	New York	100	81	78	73
N. Carolina	Raleigh	98	82	80	45
	Wilmington	94	81	79	53
N. Dakota	Fargo	105			58
Ohio	Cincinnati	106	81	78	54
	Cleveland	101	79	76	60
Oklahoma	Tulsa	106	79	77	
Oregon	Portland	99	70	68	43
Pennsylvania	Bellefonte	96	78	75	
	Pittsburgh	98	79	74	56
S. Carolina	Charleston	98	82	80	81
S. Dakota	Huron	106	76	74	56
	Rapid City	103	71	66	
Tennessee	Knoxville	100	79	76	59
	Memphis	103	83	80	58
Texas	Amarillo	101	75	70	65
	Brownsville	96	80	79	80
	Dallas	105	80	76	63
	El Paso	101	72	69	60
	Houston	100	81	79	63
	San Antonio	102	83	82	56
Utah	Modena	97	66	61	
	Salt Lake City	102	68	64	53
Washington	Seattle	86	70	67	59
	Spokane	106	68	58	41
Wisconsin	Green Bay	99	79	75	53
	La Crosse	100	83	81	69
Wyoming	Rock Springs	91	62	58	

plains regions, whereas the present availability is the reverse.

Wind Data

Wind Movement During the Summer Period

While there is a definite trend of winds in the various sections of the country more or less characteristic of the season, the proportion of time the wind blows from the preponderant direction is not as great as is commonly thought. On the map in Fig. 11, the average hours that the wind blows from each direction in July have been portrayed at 71 locations throughout the United States. Here again the geophysical influence is directly noted. Starting on the East Coast, the preponderant direction is from the Southwest, in the Northern part to Southeast in Florida, breaking into indeterminate expectancy over the Eastern mountain range, and showing a definite tendency to winds from the South in the Mississippi Valley. The broken country through the Rockies shifts the preponderant winds at right angles at some locations relatively close together, as, for instance, the group of six cities whose graphs are intercepted by a line from San Francisco to Havre, Mont. In this group Boise and Fresno lie at relatively low elevations, and Winnemucca and Helena at considerable heights. It is of interest to note that a map of this same character covering the annual wind movement shows the preponderance of movement over the 12 months to be in the same direction as for July for approximately 90 per cent of the locations, although in each case the percentage of total time that this direction exists is less on the annual basis.

With reference to wind velocities, for which the July average value in miles per hour is shown in the circle at each location on the map and the maximum recorded velocity for the entire 12 months is included in Table 2, considerable judgment and understanding of the individual location must be exercised in adopting any figure in the design of equipment. Wind values, perhaps more than any other variable, are decidedly affected by the location of the observation. Velocities near the ground are normally lower than those at higher elevations and the character of surrounding obstructions has a great deal to do with the readings. A location anywhere in the center of a large city is affected by the mountainous character of the surrounding objects which obstruct air movement, generate convection currents and cause mechanical turbulence. Neither the direction nor the velocity taken at another location can be accepted without question as applying to the observed point. If taken on the top of a building, the observations are being made on strata of higher velocity than normally exist near the ground. For instance, the records of the Climatological Station instrument, located on top of the Whitehall Building in New York, at an elevation of 304 ft above street level, show a July average over the 20 years of record of 12.6 mph. The Central Park Observatory of the City of New York, on the other hand, whose anemometer is 62 ft above the ground, shows an average of but 8.7 mph during July for a period of 17 years.

For those designs affected by the maximum wind force, such as the strength of building construction, a wind velocity well above the maximum recorded value should be used, this intensity frequently being set by building codes. For those designs where the reasonable expectation of minimum velocity dictates, values well below indicated averages should be chosen, both because the reference data are taken at considerable elevations and since every location experiences periods of calm, or zero wind velocity, especially in the summer months. It is recommended that values not over half of the average velocity values shown on the map be chosen for the design of such installations, as the wind intensity will be even less than this chosen value for from 20 to 50 per cent of the time, depending upon the location, and especially so in those locations having low averages.

Sunshine Data

Sunshine Distribution Throughout the United States

The use of solar radiation data in design cannot, in the present status of data available, be used as accurately as those covering the other factors. This is due to lack of widespread data on the intensity of the sun's rays, coupled with incomplete research on the application of

such data, if they existed. In only a few locations throughout the United States are any records taken of solar radiation. Even though such records existed from all of the 200 Climatological Stations, for instance, it would be impossible to prepare a reliable comparative map containing solar radiation values safe for design purposes, similar to Figs. 7, 8 and 9 on temperatures. Each of the records would fit the peculiar characteristics of that one location only, and a very few miles away would find different values, as sunshine intensity is most seriously affected by entirely local mechanical characteristics. It is theoretically a constant at all points on the same elevation and latitude, for the same hour and day of the same individual year. Practically, that fixed intensity is reduced by the amount of moisture, dust and smoke in the air. Thus, a measurement of the sun's intensity at one location becomes, if compared to the theoretically possible intensity, purely a measure of relative clarity of the local atmosphere. The dry-bulb temperature, to a certain extent, reflects this value and is at the present time the only general comparative measure, although a poor one, of the sun's intensity.

A certain usage may be made, for comparative purposes, of the average hours of sunshine per day, month or season. Comparison between the actual hours experienced to those theoretically possible, permits an approximation of the total sun load per season through the use of any one of a number of tables available showing the heat gains at times of full sunshine for various latitudes on surfaces of different exposures, textures, colors, etc. The map in Fig. 12 illustrates the average actual daily hours of sunshine in the season of June through September with lines of maximum possible sunshine shown for comparative purposes.

Again the effect of the geophysical characteristics may be observed, although not with the predictable result as in the case of temperatures. The mountain ridges in the East and through Wyoming have a reduced number of hours of sunshine, compared to surrounding territory. This is due to the broken character of the country, rather than the elevation, since the general trend of duration of sunshine per day increases from the Mississippi to a high point in California. The West Coast has greatly reduced sunshine compared to the mountainous region a short distance inland, which is the exact reverse of the situation on the East Coast.

Summary

Except for the years of Aerological data utilized here, there are no data available in usable summarized form in the records of the Weather Bureau that will permit a uniform investigation of temperatures over the full 24-hour daily period. The four years used were slightly higher in dry-bulb temperature on the average than the mean of the maximum and minimum temperatures for all of the years of record at the corresponding Climatological Stations, but the differentials were not great enough to do more than render the final results conservative. In those locations where additional years of data were available, comparisons were made to the data developed, and it was found that doubling the period of analysis made no practical change in the results.

The preceding survey is a report of the present status

Fig. 11—Summer wind data

of research extending over the past eight years. An earlier product of this research appears as design temperature recommendations in THE GUIDE of the Society. These present published data in THE GUIDE are based on the only data available at the time they were developed, consisting of the regularly published data as contained in Figs. 1 and 2, and average maximum dry-bulb data as accumulated by the Climatological Division, coupled with a computed depression of the wet-bulb temperature. That these data differ from those of this latest analysis is further proof of the danger of inaccuracy resulting from the use of average or maximum data in the developing of weather design data.

Further study of solar radiation should be made on a national scope. While information on this subject could not be utilized practically at the present time, it will become increasingly important, and by the time sufficient data can be accumulated, proper use can be made of the results. Additional studies of wind movement are being made at present by the Weather Bureau, and in view of the relatively minor use of data on wind in the heat exchange industry, more detailed investigation seems unnecessary at the moment. It is very much to be desired that wet-bulb temperatures over the entire 24-hour period be taken and made available to the public by the stations of either the Climate and Crop Weather or the Aerological Divisions of the Weather Bureau, as such readings are necessary for comparison in detailed studies of local conditions.

These local researches are needed to answer the questions as to the temperature differentials existing between different points in the same city. Undoubtedly, spot temperature readings at street level in larger cities have neither the same simultaneous values nor do they follow the exact daily cycle of the reference readings at the Weather Bureau. It is believed, however, from a comparison of Climatological and Aerological data, that the average daily temperatures will not be affected greatly by such differences in location, but the daily peaks and valleys of the temperature curves will be both foreshortened and delayed by the heat absorption of the masses of masonry, concrete and steel in the center of a city. Studies of this nature to date have been of a sporadic nature, usually incomplete, sometimes inaccurate, and frequently have done more harm than good, due to the misleading character of the resulting data. Such investigations, conducted in a uniform, accurate manner throughout the country by interested local organizations would be of the greatest value in most accurately adjusting the design conditions to fit the operating requirements of the individual problem.

Conclusions

The development of satisfactory data for design requires readings taken at uniform intervals throughout the 24-hour daily period. Neither maximum readings nor average readings are sufficient to establish a basis for design. Maxima in the various factors do not exist simultaneously. The data presented are a sufficiently complete forecast of the normal expectancy in weather performance to be used in design at all points East of the Rocky Mountains, and are a reasonably correct

14.6
14.3
14.0
13.7
13.4
Average number of actual hours of sunshine per day for the months June to September inclusive of a normal summer.
Broken lines are possible hours of sunshine per day during the same season

Fig. 12—Summer sunshine data

guide for Western valley locations. More detailed information regarding individual localities should be collected by local interests, but such local effort should be coordinated throughout the country. Additional investigation of weather expectancy of value to the heat exchange industry throughout the country will be possible only through more complete reports of the Weather Bureau than are at present available.

Acknowledgments

The accumulation of unpublished Aerological data was made possible through the cooperation and assistance of D. M. Little, chief of the Aerological Division, and P. A. Miller, also of the Aerological Division. L. P. Harrison assisted with data and advice regarding the behavior of weather phenomena. J. B. Kincer, chief of the Climate and Crop Weather Division, gave suggestions and provided office space for use during the collection of information from the Climatological Division. W. W. Reed of the Climatological Section furnished data on the type of wind analysis presented and directed the search of the Climatological temperature files.

The data included in the analysis are based upon the program of necessary factors adopted by the American Society of Heating and Ventilating Engineers' Technical Advisory Committee on Weather Design Conditions. Original records from the United States Weather Bureau were obtained and analyzed by the author in cooperation with the Society's committee composed of T. H. Urdahl, chairman; J. C. Albright, E. W. Goodwin, J. B. Kincer, J. W. O'Neill, John Everetts, Jr., A. C. Grant, O. A. Kinzer and L. S. Ourusoff.

Great Lakes Summer Meeting

The Council announces that the 1939 Semi-Annual Meeting will be held at The Grand Hotel, Mackinac Island, Mich., July 4-5-6 with the Michigan Chapter and the Western Michigan Chapters acting as hosts to the members and guests.

This meeting will be called the Great Lakes Summer Meeting, with the Illinois Chapter and other chapters of the Society bordering on the Great Lakes cooperating towards making it one of the largest attended Semi-Annual Meetings in the Society's history.

Mackinac Island is one of the most noted pleasure resorts in the country, rich in historic interest and scenic beauty, where all the summer recreations of deep lake fishing, swimming, golf, carriage and horseback rides through 50 miles of wooded lanes, as well as many other sports, may be enjoyed after morning technical sessions are concluded. Incidentally, this island is the only place in the country where automobiles are not allowed, and is often referred to as The Bermuda of the North.

Interesting technical sessions are now being planned and headquarters of the meeting will be The Grand Hotel. Its two-block long veranda, overlooking the celebrated Straits of Mackinac, and beautiful tea gardens are a sight never to be forgotten.

The dates selected, July 4-5-6, will permit members who desire to enjoy a cruise to use the regular sailing dates of the Georgian Bay Line which operates only exclusive passenger ships, the S. S. South American and S. S. North American through the Great Lakes.

Many members of the Society will probably plan to attend this meeting at Mackinac Island, Mich., as a part of their summer vacation and the additional feature of a Great Lakes cruise at very nominal expense is inviting. Members and guests from the East may board the S. S. South American at Buffalo leaving Saturday 12:15 p. m., July 1; Cleveland, Saturday 11:59 p. m., July 1; Detroit, Sunday morning July 2 at 10:30 a. m. Cruise trip extends over Monday, July 3, into beautiful Georgian Bay where sightseeing and shopping tours on Canadian soil can be made at Midland and Owen Sound, Ont., and then continuing the cruise to Mackinac Island for the meeting and technical sessions July 4-5-6. When returning the S. S. South American leaves Mackinac Island late Thursday afternoon July 6, and sails directly to Detroit arriving there Friday noon July 7; Cleveland Friday night, July 7; and Buffalo, early Saturday morning July 8.

For members and guests from the West boarding the S. S. North American out of Chicago, the cruise starts Saturday July 1, 4:30 p. m., stops Saturday night in Milwaukee (in case sufficient number make reservations) and continues through Lake Michigan into the Straits of Mackinac Sunday afternoon with a short stop-over at Mackinac Island for those not wishing to continue the voyage into Georgian Bay where ASHVE members on board the S. S. North American meet members aboard the S. S. South American at Owen Sound, Ont. Guests on board the North American transfer to the South American and it continues its cruise to Mackinac Island for the meeting July 4-5-6. Western members and guests leave Mackinac Island Friday morning July 7 for Milwaukee and Chicago arriving at Chicago early Saturday morning July 8.

Sailing schedules given are the regular ship cruises and accommodations are open to the general public as well as the Society's own members and guests. Early reservations are given first choice when locations of staterooms are allotted. The Committee on Arrangements urges immediate boat reservations if members anticipate making the lake voyage as the holiday period of July 4 is always a popular one for cruises on the Great Lakes.

Those desiring to motor will find excellent roads to various ferry points and the railroads run through car service from Detroit, Chicago and other cities.

Pittsburgh Experiment Station of the U. S. Bureau of Mines where the Research Laboratory of the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS is located

Air Conditioning in Industry

Physiological Reactions of Individual Workers to High Effective Temperatures

By W. L. Fleisher,* A. E. Stacey, Jr.,**, F. C. Houghten,*** and M. B. Ferderber, M.D.†, (*MEMBERS*)

(Part 2)

Report of Tests

Of the nine subjects participating in the study, seven were college students of normally good health, ranging in age from 18 to 24 years; the eighth was a 55 year old carpenter; while the ninth was a 30 year old colored man usually employed in the electrical manufacturing industry. Before accepting a prospective subject for the study he was subjected to a thorough physical examination by a practicing physician.

In Table 1 are included the following general information: the initials of the subjects, the symbols used in analyzing and plotting their data, their pertinent physical characteristics as found in the preliminary examination, and some of their physiological reactions when seated at rest in a fairly comfortable, well-ventilated but not cooled or air conditioned control room. The clothing worn by the subjects included light-weight undershirts without sleeves, shorts, light trousers, socks, and shoes.

Test Procedure

The subjects reported for test about 8:30 A. M. and entered the control room, where they were seated at rest for 45 min or longer. It was assumed that their physiological reactions would readjust themselves during this time. The re-adjustment would be from equilibrium with the morning activity including coming to work, to an equilibrium with a normal resulting from rest in a comfortable atmosphere. During occupancy in the control room, observations for each subject were made of body temperature, pulse rate, vital capacity, leucocyte count, blood pressure, weight, body and forehead perspiration, and feeling of warmth. Some of the observations were made on a number of occasions during the 45 min period, while other observations such as leucocyte counts, which were difficult to make and which required special technique and assistance, were made less frequently.

At the close of the 45 min period in the control room,

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Presented at the 45th Annual Meeting of the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS, Pittsburgh, Pa., January, 1939.

Table 1—Characteristics and Control Room Reactions

SUBJECT		C. J.	D. I.	R. T.	G. D.	B. G.	J. A.	R. S.	L. E.	J. S.
SYMBOL		▲	○	●	V	X	■	⊡	·	△
AGE – YEARS		30	18	21	23	20	55	23	24	24
WEIGHT – POUNDS		160	150	139	155	138	142	150	150	140
HEIGHT – FT. – IN		5-6	5-9	5-5	5-10	5-10	5-10	5-6	5-6	5-9
BODY SURFACE AREA SQUARE METERS		1.81	1.81	1.68	1.86	1.78	1.78	1.75	1.75	1.79
BASAL METABOLISM CALORIES/M²/HR.		–	40.8	43.0	43.2	34.8	–	49.8	32.3	42.9
BODY TEMPERATURE °F	MAX.	98.8	99.5	99.1	99.5	99.9	99.7	99.6	99.8	99.4
	AVE.	98.6	98.6	98.5	99.0	99.0	98.9	99.3	99.2	98.7
	MIN.	98.4	98.3	97.8	98.4	98.5	98.0	98.6	98.5	98.4
PULSE RATE BEATS PER MIN.	MAX.	68	98	82	82	100	88	104	93	110
	AVE.	66	72	73	76	77	80	82	86	93
	MIN.	64	63	67	68	68	72	70	81	80
VITAL CAPACITY CU. CM.	MAX.	3298	4161	4326	4841	4532	3090	3811	3955	4700
	AVE.	3193	3729	3935	4388	4367	3090	3667	3955	4408
	MIN.	3090	3399	3543	4202	4079	3090	3502	3955	4120
LEUCOCYTE COUNT PER CU. MM.	MAX.	–	7100	8000	–	8000	–	–	–	8000
	AVE.	–	6567	7767	–	7214	–	–	–	7300
	MIN.	–	6100	7400	–	6300	–	–	–	6400
SYSTOLIC BLOOD PRESSURE MM. HG.	MAX.	117	110	118	124	112	124	110	98	120
	AVE.	110	104	114	117	103	123	107	94	115
	MIN.	108	96	112	102	92	122	104	90	110
DIASTOLIC BLOOD PRESSURE MM. HG.	MAX.	80	75	78	81	78	80	74	66	79
	AVE.	77	69	77	73	71	77	70	65	77
	MIN.	75	66	76	64	62	75	66	62	72

the subjects entered the test chamber where they engaged in a predetermined physical activity for four hours, excepting for very hot test conditions when it was necessary to shorten this period. During their occupancy in the test room frequent observations of the physiological reactions of the subjects were made and recorded, in order to determine the variations of these reactions from those established as normal in the control room. A final observation of all the pertinent physiological reactions was made just before each subject left the test room. After leaving the test room when particularly hot conditions had been maintained and the body temperature and pulse rate had been considerably elevated, the subjects were required to re-enter the relatively comfortable atmosphere in the control room until their reactions became substantially normal. Then they usually had a shower and returned to their everyday activity.

Tests were conducted five days a week with little interruption from July 7, 1938 to September 6, 1938. Provisions were made for having four subjects in the test room, and with few exceptions this number participated in each test. Having nine subjects available allowed some modification of the frequency of tests on any one individual. The seven students participated in the greater number of tests, and only a few tests were made with the two older men.

Physiological Observations

The plans for the study included observation of all the physiological reactions of the subject which might respond in any measurable degree both to his activity and to the atmospheric conditions maintained in the control room. All of the physiological reactions listed in Table 1, as well as the loss in weight, the degree of sensible perspiration on the forehead and body, and the feeling of warmth, were observed for all the subjects in all of the tests. The metabolic rate, the blood pressure, and the leucocyte count, all of which required special equipment and technique, were not always taken for all the subjects in the various tests.

A practicing physician with special training and experience in physiological research, who was connected with the Department of Industrial Hygiene of the School of Medicine of the University of Pittsburgh, was at all times available for consultation and aid in carrying on the work. He actually participated in the more difficult physiological measurements in many cases, but when he was not available a senior medical student of the University working under his supervision aided in making these observations.

The activity during the morning, including breakfast and coming to work, and in some cases the somewhat elevated temperature in the control room may account for some of the slightly elevated body temperatures, pulse rates and leucocyte counts. The body temperatures were observed rectally with clinical mercurial thermometers, and it was found that the averages were much nearer 99 F than the conventionally assumed 98.6 F. In this connection it should be kept in mind that body temperatures observed rectally are usually somewhat higher than those observed orally. The values given in Table 1 also serve to emphasize the fact that there is considerable variation in the body temperature of different normal persons, and also in the body temperature of the same person at different times. As seen from Table 1, the group gave a minimum to maximum range of from 97.8 to 99.9 F.

The pulse rate was observed by counting the wrist pulse with a suitable timepiece. The vital capacity, expressed in cubic centimeters, was determined as the maximum volume of expired air which the subject could blow into a calibrated spirometer at one exhalation at the time of observation. It will be observed that this varied considerably in the control room for the different subjects and to some extent for the same subject on different days.

The doctor or medical student always made the leucocyte count, and it was found that the normal values taken in the control room and included in Table 1 were a little high for what is generally accepted as normal. However, this may be due to the fact that these observations were usually taken within 1½ hour after breakfast, followed by the exertion incident upon coming to work. The systolic and diastolic blood pressures were observed in the manner usually used by doctors, with instruments including a mercury manometer.

The basal metabolic rate and the metabolism both while seated at rest and while working were determined by the indirect method used in earlier laboratory studies

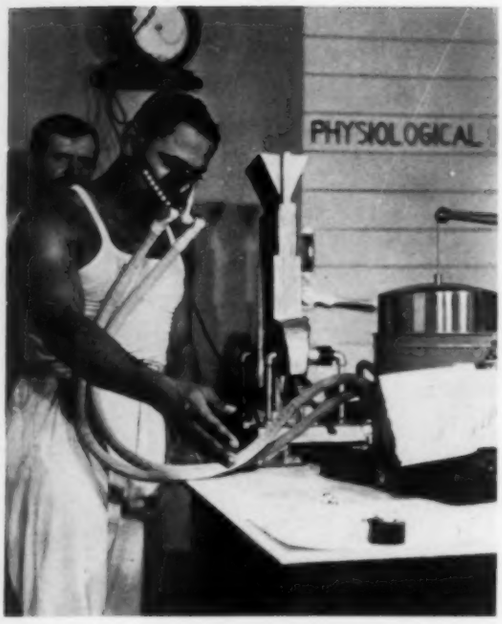

Fig. 3—View of test table with chance machine showing metabolism determination on subject, C. J.

of heat and moisture loss from the body. Between the wearer's mask and the apparatus was provided a 4-ft hose connection, which allowed the subject sufficient freedom for the work required of him. This work was continued uninterrupted with his wearing the mask for several minutes before and during the actual determination.

The loss in weight was determined by weighing the subject on scales accurate to ½ oz, first in the control room just before his entering the test room and again before his leaving the test. Since a record was kept of water consumed and urine excreted during this period, the loss in weight was corrected accordingly. Hence, the loss in weights given are net loss due to perspiration and carbon expired as carbon dioxide.

The observation and recording of condition of perspiration on forehead and body were made in accordance with a scale of degree of perspiration adopted and used in earlier studies at the Laboratory. According to this scale, entire freedom from sensible perspiration is given the index of zero; clamminess, "1"; dampness, "2"; wetness, "3"; and running down or soaking through clothing of perspiration, "4."

The degree of feeling of warmth or comfort was observed also in accordance with a scale used in earlier studies at the Laboratory. According to this scale, ideal comfort was expressed as "4", slightly warm and slightly cool conditions by "5" and "3", respectively, decidedly warm and decidedly cold conditions by "6" and "2", respectively. Since all of the tests in this study were at temperatures at or above those giving a feeling of ideal comfort, only indices of "4", "5" and "6" were necessarily used. The measure of the degree of comfort or perspiration by these arbitrary indices is rather difficult and may be subject to considerable variation or possible error in observations, due to the observer's misconception of just what degree of reaction a given index number is to represent, and to his inability to interpret this degree properly at times. Particularly in the case of the comfort reactions, difficulty was experienced in this study; for frequently, the subjects were working in hot atmospheres as compared to earlier studies in which the subjects had been at rest in relatively comfortable atmospheres, or atmospheres only slightly too warm or too cool for comfort. Accordingly, the index previously used was slightly modified in this study in its interpretation. A comfort index of "4" in this study, as in the earlier ones, represented ideal comfort. It was rather surprising, however, to find that the subjects in this study while working in atmospheres of 77½ deg ET, and sometimes as high as 82 deg, said they were comfortable; whereas in earlier studies the subjects were rarely found to be comfortable during the summer time in atmospheres of 75 deg ET, and more often the upper limit of comfort in the earlier studies was found to be around 73 or 74 deg ET. This difference may be accounted for in one of two ways. It is possible, and even probable, that the extra body surface area exposed to normal heat loss to the atmosphere for a person standing is more appreciable than for a person seated; further, the added effective air motion over the surface of the body for a person standing up and moving about may actually serve to increase the rate of heat loss to an extent greater than the added rate of heat production in the body by metabolism due to the activity of movement. The second reason may be psychological in that a person engaged in some activity is less likely to have his attention directed to a feeling of slight discomfort caused by higher atmospheric temperatures, as in the case of a person at rest.

A comfort rating of "5" in this study was made to include observations of rather decidedly warm but still bearable conditions, while "6" was made to include conditions which were very hot and more or less unbearable.

Test Conditions

The study included observations of the physiological reactions of the subjects while at light work in atmospheres ranging from 77½ to 92½ deg ET, and for 60, 75 and 90 per cent relative humidity. At each of the three humidities studied, tests were made at approximately 77½, 80, 82½, 85, 87½, 90 and 92½ deg ET. For at least an hour before the subjects entered the test room the air temperature and moisture content were kept constant at the predetermined values within the accuracy of one degree dry-bulb temperature and one per cent relative humidity. The wet- and dry-bulb temperatures, recorded automatically, were also observed by a fan-operated psychrometer consisting of wet- and dry-bulb thermometers so arranged that the fan drew the air over them at a velocity of approximately 2000 fpm. Both the recording and the previously mentioned indicating instrument were frequently checked by a sling psychrometer. The air motion within the test room always ranged from 30 to 40 fpm, which was the movement necessary to maintain uniform conditions. In this study no attempt was made to include the effect of air movement on the physiological reactions of the subjects.

Fig. 4—View of subject having blood sample taken and analyzed for determination of leucocyte count

Fig. 5—Determining vital capacity of subject, J. A.

Fig. 6—Weighing subject, C. J., for perspiration loss

Activity of the Subjects

This study was entirely limited to the physiological reactions of workers engaged in what was called *light work*. The type of work agreed upon by the Committee required the subject to be on his feet approximately three-quarters of the time, to move about performing light tasks entailing some but not severe muscular activity; and above all the work required that the subject be alert and attentive to his task. This attentiveness of the subject was the most difficult to provide for, since it is a well recognized fact that a person performing a routine physical effort may soon learn to perform that task when he is practically asleep mentally, or when his mind may be occupied with thoughts entirely extraneous to the work performed. To make attention an essential part of the task required that some element of chance should determine the particular duties that the subject would be called upon to do and the time when they must be done.

A chance machine shown in Fig. 3 was developed into which each of the subjects dropped a small ball, or marble, each subject's ball being distinguished by color. After this ball was dropped into the machine, the chance operation of the machine delivered it within the interval of ½ and 2½ min. Therefore, during this time the subject was required to be attentively watching the exit of the machine to see when his particular ball emitted. When that subject's ball emitted he immediately threw two dice, one of which determined the particular weight of a series, ranging from ¼ to 1¾ lb, that he had to pick up from the table, while the second die determined the new position on the table where he had to place the weight. Since there were six places on the table and each subject had six differently numbered weights, considerable attention was required in choosing the right weight and putting it in the right place. When replacing the weights each subject was required to move around the table in performing his task rather than reaching across the table to do so. When these tasks were performed the subject was required to record the time, the particular weight he picked up, and the location where he placed it. While performing these duties, the subject also observed and recorded various physiological reactions such as his body temperature, pulse rate, degree of perspiration, feeling of warmth, and at intervals blood samples were taken for analysis as illustrated in Fig. 4 and also the vital capacity was determined as shown in Fig. 5. Each subject was weighed during the test to indicate perspiration loss as illustrated in Fig. 6.

[To be continued in April]

MEMBERSHIP CARD

The 1939 Membership Card issued to all members upon payment of current year's dues is a canary tint with brown border. They are now ready for distribution.

Smoke Abatement—Where to Draw the Line

By H. B. Meller,* Pittsburgh, Pa.

IF AIR pollution abatement is to make the advances demanded in cities, it seems clear that ordinances and methods of enforcement need to be scrutinized. Excellent work has been done by smoke-ordinance enforcement officials and their staffs, working under the conditions prescribed by law, in many localities. The demand is for more law enforcement in abating smoke nuisances and more of this mandatory regulation will be forthcoming in various communities. The responsibility rests with those familiar with the difficulties to see that the development is sound and along logical lines.

Current Pittsburgh Survey

Before discussing provisions of ordinances and possible methods of securing better results from enforcement, mention should be made about some of the information now being collected in Pittsburgh through a WPA grant. While there are many phases of this project, special interest at the moment is in the amount of dirt in the city and the sources from which it comes —in other words, soot fall plus visual observation of stacks.

For these purposes the city is divided into 100 districts, in each of which is a station for collection of sootfall by the method usually followed. There are 50 observers, each of whom works approximately 120 hours a month (6 hours a day for 20 days, part of the time from early morning until noon, and part of the time from noon until evening). Thus each man covers two of the sootfall districts, reporting source, density and duration of any smoke observed. Naturally, the observer cannot at one time see all of the stacks in a single territory, but this method of analyzation gives a fair coverage.

The data compiled at this time cover only the period from April through November, 1938. They are not to be considered conclusive but merely as illustrative. However, as investigators are desirous of analyzing results as they are tabulated, some interesting comparisons will be shown herewith. Bear in mind that additional data collected during the current year may change the picture materially.

The average sootfall shows the usual seasonal difference, varying from 85.1 tons per square mile in April to 39.6 tons per square mile in July, and back to 78.8 per square mile in October. Later months, November through March, will be higher.

The effect of topography, which has been referred to in previous papers, is interesting. The sootfall collection stations were divided between hill and valley locations. Averages for the hill stations are consistently about two-thirds as high as those for the valley stations.

From the reports of the observers an estimate of the volume of smoke should be possible later. This is highly important, since it takes as long for a smoke inspector to observe a small stack as a large one. At this stage of the study, however, the records show density and duration of each smoke and the stack from which it was emitted. Therefore in this paper reference will only be made to the *number of smokes*.

For the period under discussion, 66 per cent of all smokes reported were light in density (No. 1 Ringlemann Chart, or less), 21 per cent medium (No. 2) and 13 per cent dense (No. 3 or heavier).

Fuel-burning plants are classified as heavy industrial; light industrial; commercial, including heating plants in office buildings, stores, apartment buildings, etc.; and domestic. In the classes regulated by city ordinances are approximately 5000 stacks. In the city there are 154,000 dwelling units, in 119,000 of which the fuel used is coal; none of these is subject to smoke regulation.

Considering dense smoke only, a comparison of the various classes of plants is as given:

In March, for example—a high month for total smoke—of 21,439 cases reported, 2 per cent were in heavy industry, 6 per cent in light industry, 20 per cent commercial and regulated heating plants, and 72 per cent were domestic.

Contrast that with July. Of 5270 cases reported (and supervision over industrial plants was concentrated during the summer months), 18 per cent were in heavy industry, 54 per cent in light industry, 26 per cent commercial, and 2 per cent domestic (incinerators).

In November there were again 14,238 cases—4 per cent in heavy industry, 7 per cent in light industry, 18 per cent commercial and 71 per cent domestic.

The indications are that roughly 80 per cent of the winter smoke from buildings in the commercial class was from heating plants.

Conclusions are not to be drawn from these very incomplete data. Upon completion of the survey, this and other phases of the air pollution problem will be carefully analyzed. In this the assistance of selected groups of physicians, engineers and other specialists will be sought.

Ordinances and Enforcement

What do the few data herein presented indicate? The indications are that the smoke abatement staffs of the cities are too small to maintain observational and inspectional supervision over their territories—which has always been known of course; and that major changes are needed in ordinances and in methods of enforcement. The latter item is especially true with regard to low

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pressure plants, including the enormous number of domestic boilers and furnaces.

Visible Smoke

A *Model Smoke Abatement Ordinance* prepared by the *Smoke Prevention Association* contains this section: "The emission of dense smoke within the city from the smoke stack of any locomotive, steamboat, steam tug, steam roller, steam derrick, steam pile-driver, tar kettle or other similar machine or contrivance, or from any open fire or from the smoke stack or chimney of any building or premises, excepting for a period of six minutes in any one hour during which the firebox is being cleaned out or a new fire built therein, is hereby declared to be a nuisance and may be summarily abated. . ." Many industrial cities are now operating under such provision—no dense smoke except as specified, and no exemption for any class.

Probably this is as close as the limit should be drawn at this time, although fires *can* be cleaned and new fires *can* be built with little or no dense smoke. However, the belief is that an operation which can be carried on normally without dense smoke can also be carried on with the production of a limited amount of No. 2 smoke—for example 5 or 6 min at any one period.

For the present consider the matter of supervision, with inspectional forces in the large industrial centers in ratios (inspectors to population) of 1: 60,000 to 1: 250,000. Obviously the present methods of observation —inspection—instruction are not adequate, and a system should be devised which will result in satisfactory overall control with a limited official personnel.

Fly-Ash

The control of fly-ash is now considered a necessary part of the smoke abatement program. The term has come to mean ash plus cinders plus coke—in other words, visible smoke and fly-ash together include all solid products of combustion. Fly-ash is prohibited in 33 of 77 cities whose ordinances were analyzed by the *Smoke Prevention Association*. Eighteen of these apparently have no provision for enforcement; nine require only screens at the top of the stack; only six appear to have definite requirements covering the installation of dust separating equipment. As it is known that emission from domestic and other small chimneys is relatively high in tar and carbon particles and relatively low in ash, it is also known that the reverse is true of the larger stacks with their better combustion and much higher gas velocities.

The amount of fly-ash which should be permitted has not, as far as is known, been determined. In several cases the limit is set on the basis of density by visual observation. Whatever limit is considered fair, it means that actual sampling is necessary to determine compliance or violation. These are relatively lengthy procedures and the number of tests that can be made is limited.

Gases

In a number of cities the ordinances regulate the emission into the atmosphere of noxious and obnoxious gases. The only product of the combustion of fuel that is concerned is sulfur dioxide. Most of the sulfur in stack gases is in this form. Such a regulation opens up a wider field, however,—industrial gases, which locally may in some cases reach a concentration that is an annoyance, or even a health hazard. There are methods of determining the concentrations of the various gases that may be encountered.

Anti-Smoke Ordinance

Consideration should now be given to the so-called *anti-smoke ordinance*, which is aimed at control of products of combustion. Whether or not more than dense smoke is specified, the enforcement officer finds that his work includes abatement of fly-ash and sulfur gases. And whether or not private dwellings are exempt, an appreciable percentage of his time and that of his inspectors will be devoted to domestic smokers. Therefore, it is logical and proper that, in addition to the regulation of smoke, excessive fly-ash and sulfur gases should be prohibited. As stated previously, this prohibition is found in the later ordinances in effect in many cities. There should be no exemption of any class of fuel-burning plants.

Permissible Limits. As the limitation of dense smoke to 6 min during cleaning or building a new fire, with none allowed at any other time, is considered satisfactory in a high percentage of large industrial cities, such a provision would seem to be in line with current good practice. In addition, smoke of medium density (No. 2, Ringlemann Chart) could be limited to 5 or 6 min in an hour.

Excessive fly-ash should be prohibited, but to agree on what the limit should be in fairness to all concerned is difficult. The most recent suggestion is 0.5 grains per cubic foot of gas on stoker-fired installations and 0.75 grains on pulverized coal-fired installations. There must also be a simple method of checking in order that this part of the ordinance may be properly enforced.

The situation with regard to sulfur gases is different. There is at present no practicable method, for use in medium size and smaller plants, of neutralizing or eliminating these gases. One way to reduce the total amount of sulfur that gets into the atmosphere is to place a limit on the percentage of sulfur in fuel that may be burned, which is now being done in St. Louis.

Enforcement

Enforcement is the greatest barrier to real success in smoke abatement. An ordinance can be specific as to what is permissible and what is prohibited, but without adequate means of enforcement it is worth comparatively little. The number of inspectors in the large industrial cities varies from one to 60,000 population to one to 250,000 or more. Pittsburgh's ratio is about midway between the two mentioned.

An inspector can cover only a limited area in a day. Regularly he has inspections to make, violations to investigate, complaints to follow up, firemen to instruct; besides other duties that come up occasionally. Corps are too small to keep up efficiently with their special duties, aside from smoke observations on industrial and

commercial plants; this is exclusive of private homes, which introduce special problems. Conditions cannot only be interpreted on the basis of the reports of the smoke inspectors.

City Councils have allocated to smoke abatement such proportion of total income as they consider fair. A request for a sufficient increase in personnel to make possible the kind of supervision which the abatement officer would like to have would be met with refusal as being out of proportion with other necessary services.

Since it is not possible to do a complete job by the methods that have been in use, obviously new or different ways must be developed. Although considerable thought has been given to the matter, the extent of this paper does not permit discussing it in any detail. Such a plan naturally would regulate really to *prevent* violations, and would involve more specific regulations and place more responsibility upon owners.

To meet the demands of the public, it is going to be necessary, first, to draft laws that will make possible the measure of air purity it desires; secondly, to bring people to a realization of the fact that the low pressure heating plant as used in small commercial establishments, apartments and private houses is, in proportion, the worst offender; and thirdly, to secure their cooperation —willingly in most cases, arbitrarily in some.

Industrial Dusts, Fumes and Gases

Another phase of air pollution which has been receiving attention is that which comes from raw materials used in industry and from industrial processes. Its control within the plant is an engineering job in air conditioning. That part of it will not be discussed in this paper, but where dusts, fumes and gases are in such concentrations as to be noxious or obnoxious they should not be exhausted into the atmosphere, but should be disposed of in some other manner.

Conclusion

The purpose of this paper will have been accomplished if the writer has convinced the reader of his own belief that the abatement of nuisance-making and health-damaging air pollution will go ahead at a greatly accelerated pace. If the conditions and their causes are analyzed, which can be done from training and experience, it is felt that readers will put their shoulders to this wheel of progress.

It is a problem in public relations, with many groups involved. There will be new and more stringent regulations, but there is no reason to anticipate that these will be in any way unfair. The rest is a matter of cooperation from interested groups—manufacturers of equipment, producers of fuel, engineers, and finally the users, who make up the public.

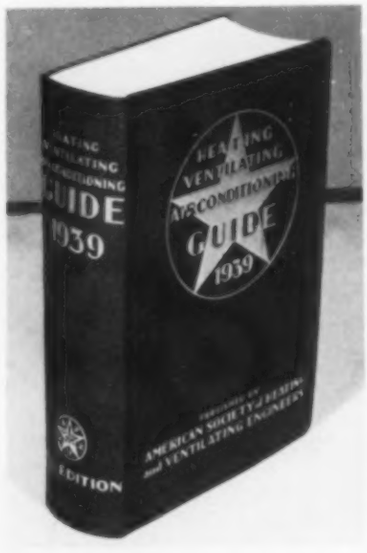
Heating, Ventilating, Air Conditioning Guide 1939

The 1939 edition of the HEATING VENTILATING AIR CONDITIONING GUIDE, which comprises 856 pages of text material, together with 270 pages of catalog data of the manufacturers, was recently released to the membership of the Society. Through the efforts of the several contributors the 17th edition of THE GUIDE reflects the outstanding research and engineering advancements which have taken place in this field of engineering since THE GUIDE made its first appearance in 1922.

Basic and fundamental data have been retained from previous editions but in this volume a concentrated effort has been made by the committee to condense and combine material throughout the text. Those chapters dealing with central systems for heating, humidifying, cooling and dehumidifying have been carefully reviewed and a completely new chapter has been prepared which incorporates all of the essential material from other chapters. The title of this chapter is Central Systems for Comfort Air Conditioning, and the material is presented in such a manner as to apply directly to the requirements set forth in the application Code of Minimum Requirements for Comfort Air Conditioning which was adopted by the Society in January, 1938.

A subject which has not heretofore received special attention in previous editions of THE GUIDE is information dealing with heat transfer surface coils for summer and winter applications. The committee presents in this edition a chapter which gives the latest information that is available on this type of equipment. Details are given describing the conventional construction and arrangement of heating and cooling coils with suggestions for typical flow arrangements of the circulating media.

The problem of fuels and their combustion was recognized by the committee this year as an important factor to the heating engineer and as a consequence a completely revised chapter on Combustion and Fuels is presented in the 1939 edition. Fundamental principles of combustion together with related factors dealing with flame temperature and proper air requirements are given special consideration. The latest current information on



classification of all types of fuels is given along with suggested methods of firing to obtain optimum results. Another chapter closely related to this subject has been rewritten this year on Heat and Fuel Utilization. Methods are outlined for estimating fuel consumption based on calculated heat losses and degree-day factors. Charts are included for coal, oil and gas whereby fuel burning rates may be estimated for various design loads and operating efficiencies.

Other chapters which have been rewritten for the 17th edition deal with Air, Water and Steam, Cooling Load, Radiators and Gravity Convectors, Steam Heating Systems, Piping for Steam Heating Systems, Mechanical Warm Air Furnace Systems, Unit Heaters, Ventilators, Air Conditioning and Cooling Units, Natural Ventilation, District Heating, Heat Transmission Coefficients and Tables, Air Leakage, Automatic Fuel Burning Equipment, Air Distribution and Automatic Control.

The new 1939 edition of THE GUIDE comprises 45 chapters of technical data, the catalog data section, the roll of membership of the Society, and complete indexes to the technical and catalog data sections. This handbook is again bound in a flexible blue cover with gold stamping and is available at $5.00 per copy. A limited number of thumb indexed copies will be available at $5.50 each for those who desire this particular feature.

Members of the Society will receive the thumb indexed edition and shipments were started February 15.

Proceedings of the 45th Annual Meeting

AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS

Pittsburgh, Pa.—January 22-26, 1939

E. Holt Gurney, Toronto, Canada
***President*—1938**

MEMBERS who attended the 45th Annual Meeting of the Society found the technical sessions intensely interesting and the hospitality of Pittsburgh Chapter most enjoyable. It was a notable meeting from the standpoint of attendance, interesting discussions, the variety of technical papers, and the fact that 1939 commemorated the establishment of the Society's Research Laboratory in Pittsburgh. It was entirely fitting that this meeting should be held in Pittsburgh and the majority of men who had served as chairmen of the Committee on Research since 1919 were present. The total registration was 570 with more than 300 members registered.

FIRST SESSION—
Monday, January 23, 1939, 2:00 P. M.

The 45th Annual Meeting of the Society was opened by Pres. E. Holt Gurney, Toronto, Ont., at the William Penn Hotel, Pittsburgh, January 23.

President Gurney read the annual report of the president.

President's Address

The general activities of the Society are covered in the report of your Council; of the Research Committee by the report of its chairman; and the financial situation is clearly set forth by the chairman of the Finance Committee. I regard progress in all these matters this year as reasonably satisfactory. There are, however, certain matters which I think it is more appropriate to discuss with the membership direct in Annual Meeting, rather than with the Council.

In the first place, I believe that we should get away from the tradition that the president should visit most of the Chapters, or all of them. I am very conscious of the fact that, as I write this, I am far better qualified to be president of the Society than when I began my term. I visited some 16 Chapters this year, in addition to the seven that I visited last year. Thus, I came to my term of office without a knowledge of the men active in the Chapters which I now possess. If your president had had the advantage of this knowledge when he appointed the committees for this year, several able men, actively interested in the work of the Society, would have had a larger part in it through membership in certain committees.

Further, while I have spoken to several outside bodies, I have had to refuse many more invitations to do this sort of thing than I have accepted, just because of the pressure on your president to visit Chapters. As the Society gains in authority, and especially as we have larger contact with the medical profession, I consider that it will be more and more important that your president be free to do this type of speaking rather than to the Chapters.

Our Constitution sets out that the president "shall visit as many of the Chapters as his convenience permits." I believe this should be changed to read, "The president, the first vice-president and the second vice-president shall visit as many of the Chapters as their convenience permits." But I am perfectly clear that, as a matter of practice, most of these Chapter visits should be made by the first and second vice-presidents. If this is done, they will better discharge their duties, when they reach the chair, and the president will be free to make very important outside contacts.

I am not of opinion that this modification of policy should be effected in one year; this would be unwise. I believe that this year, for example, your president should certainly go to the Pacific Coast, and the South; our members in these far away sections are of necessity less represented here than nearer parts of the country. I believe that this year your president should explain, wherever he goes, what is contemplated. The following year the policy could be pushed further, and it could be finally worked out over a period, say of three years. Meanwhile, the other important contacts that the president should make annually can gradually be formed.

I believe that it is very important that more of the money spent by the Speakers' Bureau should be spent in getting out-

J. F. McIntire, Detroit, Mich.
***President*—1939**

standing men for the far-away Chapters, and that less should be done for those Chapters in the great metropolitan centers of the east, especially where they are in a university town. Your Speakers' Bureau has a very difficult problem. Again and again an outstanding speaker will consent to leave his work for two nights, and this means that the Chapters who need help least have benefited in largest measure from the activities of your Speakers' Bureau. I would like to see the Speakers' Bureau finance a trip to the coast for two or three outstanding men. They could go out by Omaha, Oklahoma and Texas, and return via Winnipeg. They might consider this as a spring or fall holiday, if their expenses were paid for the trip, and I believe such a move would do a great deal to bridge the distance and the *east versus west* feeling inevitable in any great national organization, whether it be in Canada or the United States. I am sure this would make for greater solidarity in the ASHVE.

Finally, and to me much the most important item of all is your procedure in selecting Council and officers. Under our present set-up a Nominating Committee meets, consisting of one representative from each Chapter. There has inevitably, under this situation, arisen a feeling that it is the *turn* of a given district or a given Chapter to be represented. This has consequently meant that a man who has no Chapter affiliations is rather unlikely to reach office. Nearly 50 per cent of our fraternity have no Chapter affiliations, and many of them cannot have one because of the geography of the situation. Under this set-up, there is some question in my mind, whether, for example, Dr. Willard could ever have reached the presidency. I think of two or three outstanding men in the United States whom I hope to see some day in the chair of this Society, but who in their present location, find it unnatural to be affiliated with a Chapter.

Further, it seems to me that the selection of Council men each year should always keep a fair distribution as between the three great classes that make up our Society. I refer to the executive business man in engineering work, the professional engineer, and the academic man. These three groups intermingle in our Society in a way that gives so much of our strength; but when the main consideration becomes geographical, this very important phase of the matter is apt to be overlooked.

In all my associations with things that have to be done, it has seemed to me that my most important job has always been the question of personnel; yet I am now retiring from active leadership in this Society without any voice whatever as to who may come on this board in the future, or who may go on to office. It seems to me almost a truism that I must know more about this than any man who is sent here to represent a Chapter. I know this is so, because for the last two years my opinion has been sought by members of your Nominating Committee, and it is particularly so this year after my extensive travels in your behalf.

I suggest two things: first, that your immediate past president shall be ex-officio a member of the Nominating Committee, and that this be given effect to at once; second, that you appoint a committee to study this whole situation. I would suggest the president of your Advisory Council, the president of your Society, the chairman of your Nominating Committee, the chairman of your Constitution and By-Laws Committee, and, if you like, two men appointed from the floor of this convention. Surely such a group will suggest nothing which will militate against a democratic set-up. I am altogether in sympathy with the proposition that no officers of this Society shall find themselves in a self-perpetuating position; but most certainly we must do something to qualify a position in which 25 Chapter representatives meet to select our officers and directors without knowledge of the men who cannot belong to a Chapter, and without the especial knowledge which comes to a senior officer in this organization after one, two or three years' travel in your behalf.

I have difficulty in finding words to express my great appreciation of the complete and enthusiastic cooperation I have had from everybody throughout my year, and I also wish to pay tribute to the men and women in the employ of the Society for both their ability and their remarkable loyalty.

All of which is respectfully submitted.

E. Holt Gurney, *President.*

The secretary of the Society, A. V. Hutchinson, New York, read the report of the Council and the report of the secretary.

Report of the Council

During 1938 meetings of the Council were held in New York City, Buffalo, Hot Springs, Montreal and Pittsburgh. On January 28, 1938, the Council was organized and Council committees were appointed by Pres. E. Holt Gurney. Special committees required by the Constitution and By-Laws were organized; depositories for the Society's funds were selected, and a budget of $106,600 was adopted.

A. V. Hutchinson was appointed secretary; the firm of Tusa and La Bella was retained as certified public accountant to audit the Society's books. A fund of $5,000 was transferred to the Committee on Research by the Council. New offices for the Society's headquarters were selected at 51 Madison Ave., and a two-year lease was negotiated with renewal option for another year.

A technical secretary of the Society was appointed, John James, and arrangements were made for him to assist the chairman of the Committee on Research in administrative work. A plan of reorganization of activities was studied by the Council and a campaign of educational publicity was inaugurated. Authorization for the disposal of surplus publications of the Society was given and members were offered the first opportunity to purchase back numbers of the Journal and Transactions at nominal prices.

The Exchange Service Plan between the Society and the *ASRE* was renewed. Charters were authorized by the Council for three new chapters: the North Texas and South Texas Chapters and the North Carolina Chapter.

The Semi-Annual Meeting place for 1939 was selected at Mackinac Island, and the dates of the meeting are July 4, 5 and 6. The meeting place for the 46th Annual Meeting was

chosen—Cleveland, Ohio, and the meeting will be held during the fourth week in January, 1940.

Some of the special projects studied by committees during the year were research reorganization, engineering and public health, air conditioning legislation, Society standards, educational publicity, regional meetings, engineering fees for housing projects, procedure for the guidance of the Admission and Advancement Committee, and engineering scholarships.

The Council carried out its functions as required by the Constitution and By-Laws in nominating candidates to serve on the Committee on Research; voted on nominations for the F. Paul Anderson Medal; approved Candidates for Membership, and authorized resignations and cancellations of memberships.

The Council obtained legal opinion on the Society's activities under its charter, Constitution, By-Laws and Rules. It approved programs for Annual and Semi-Annual Meetings and carried on all routine activities specified under the Society's regulations.

Respectfully submitted,

THE COUNCIL.

Report of the Secretary

A detailed account of the daily operations carried on in the headquarters office in the calendar year 1938 would make a voluminous document and would include much statistical material that might prove to be very dry reading.

The main activities of the secretary's office deal with the work of the Council and special committees; production of THE GUIDE, JOURNAL, TRANSACTIONS; standards and codes; membership, which includes elections, advancements, cancellations, address changes, and dues collections; employment service; chapter activities; speakers bureau; sales promotion and publicity.

With the total membership approximately 3000 the work requires a staff of 10 people. A new activity was inaugurated this year with much of the routine administrative work on research transferred to headquarters and practically half of the time of the technical secretary was devoted to this work. This activity requires clerical and bookkeeping service and has been effective in relieving the chairman and director of research of much detailed work.

Detailed figures will be given in the various committee reports about the status of membership, the production of THE GUIDE, and the financial condition of the Society.

It is interesting to note that dues collections in 1938 just reached the 10 year average although unusual efforts were made to stimulate collections during the last quarter of the year. About 10 per cent of the membership now have one year's dues in arrears. In the survey of dues collections it was noticed that 60 per cent of total dues collected in any calendar year comes in during the first four months and the balance comes in in small percentages during each of the other months.

In compiling the Roll of Membership to be published in THE GUIDE, it was noticed that nearly 70 per cent of the members had address changes. When the first request was sent out only 40 per cent of the members responded, which added considerably to the cost of compiling the list.

A favorable increase in membership was recorded during 1938 with 380 new applications filed, but the Admission and Advancement Committee on numerous occasions found it necessary to request additional information because of inadequate information on the original application.

It would be well for every member who signs an application as a proposer or seconder to see that complete information on the education and professional experience of the candidate is given. Personal signatures of sponsors are required and it is also important that a sponsor personally know the candidate, so that he can attest to his engineering ability.

A total of 12,600 GUIDES were printed and bound in 1938 and over 12,450 were distributed; THE GUIDE was mailed in all states of the United States, all of the provinces of Canada and in the majority of countries throughout the world. Reports indicate that parts of THE GUIDE have been translated into many foreign languages and data from THE GUIDE are to be found in most of the modern texts on air conditioning and in the courses offered by schools and colleges. If all of the copies of the 1938 edition of THE GUIDE could be placed in a pile, it would be over 2½ times the height of the Empire State Building, and their weight would total 25½ tons. When it is visualized that each page of THE GUIDE is read at least four times before it gets into print and that, outside of the membership, shipments are being made in small quantities each day, there is a large amount of work involved in acknowledging orders, labeling, shipping and billing the complete edition.

Every effort is made at the headquarters office to render effective service to members and the staff is always on call for service.

Respectfully submitted,

A. V. HUTCHINSON, *Secretary.*

Report of the Finance Committee

1st Vice-Pres. J. F. McIntire, Detroit, Mich., chairman of the Finance Committee, gave the report of the Society's certified public accountant for the calendar year 1938. In commenting on the financial condition of the Society, Mr. McIntire said that dues collections were of considerable concern to the committee and that the Council found it necessary to drop members in arrears because of the expense involved in carrying men who did not pay up.

Report of Certified Public Accountant

January 17, 1939.

American Society of Heating and
Ventilating Engineers,
51 Madison Avenue,
New York, N. Y.

Gentlemen:

Pursuant to your request we made an examination of the books of account and records of the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS—New York, N. Y., and the Research Fund for the calendar year ended December 31, 1938 and submit herewith our report.

The work covered a verification of the Assets and Liabilities as of the date previously stated and a review of the operating accounts for the year ended December 31, 1938. For the period recorded cash receipts were traced into the depositories; the cancelled bank vouchers were inspected and compared with the cash records and the Dues Income was accounted for.

Submitted herewith is a Balance Sheet showing the financial condition of the Society on December 31, 1938 and your attention is directed to the following comments thereon:

CASH

Cash on Deposit was verified by direct communication with the banks and reconcilement of the amounts reported to us with the balance shown by the books of the Society.

The Petty Cash kept in the New York Office was verified by count.

MARKETABLE SECURITIES

There is attached hereto a schedule of negotiable bonds which were verified by direct communication with the Bankers Trust Company where same are deposited for safe-keeping. No adjustment has been made of the $3,862.96 shrinkage in the market value of these securities, same being included in the attached Balance Sheet at cost.

ACCOUNTS RECEIVABLE

A list of the Membership Dues Receivable as of December 31, 1938 furnished to us by the management was checked to the individual ledger cards and found in agreement with the General Ledger Control. The unpaid dues may be summarized as follows:

Dues billed in 1938	$ 6,711.28
Dues billed in 1937	2,085.75
Dues billed in prior years	5,049.60
TOTAL	$13,846.63

Amounts due from GUIDE Advertisers and Other Accounts Receivable verified by trial balance of the individual ledger accounts were found in agreement with the General Ledger Control.

The Reserve for Dues Doubtful of Collection found on the books has been increased by $3,676.58 while the Reserve for Advertisements and Sundry Receivables Doubtful of Collection has been decreased by $58.50. The adjusted Reserves now shown on the accompanying Balance Sheet in our opinion are ample to cover losses resulting from future realization.

INVENTORIES

Items appearing under this caption are based upon quantities submitted by the management and computations made by us. The Transactions Inventory priced at cost may be summarized as follows:

Prior years	$1,750.00
1932	383.10
1933-34	652.00
1935-36	51.15
1937-38	395.00
TOTAL	$3,231.25

FURNITURE, FIXTURES AND LIBRARY

Furniture, Fixtures and Library are shown herein at the book values without appraisal by us, we did, however, provide for depreciation of Furniture and Fixtures at the rate of ten (10%) percent per annum.

DEFERRED CHARGES

Items appearing under this caption have been computed by us.

ACCOUNTS PAYABLE

On December 31, 1938 there remained unpaid invoices amounting to $1,481.55 also the sum of $21,677.27 estimated by the management necessary to complete and make the first mailing of the 1939 GUIDE and Vol. 43 and 44 of TRANSACTIONS.

PAYABLE TO RESEARCH FUND

The amounts due the Research Fund representing 40% of Members and Associates Dues were determined from computations made by us in accordance with Section 5 Article 3 of the By-Laws.

ACCRUED ACCOUNTS

Additional compensation to the Secretary and the clerical staff of the Society has been computed in accordance with the instructions of the Finance Committee.

DEFERRED INCOME

Members Prepaid Dues were ascertained by trial balance of the individual ledger cards. Prepaid Dues from proposed Members were verified from inspection of the applications found on file.

GENERAL FUND

There is attached hereto a schedule showing the changes that have occurred in the General Fund during the calendar year 1938.

SPECIFIC FUNDS

The specific funds are shown on the attached Balance Sheet after adjustment for interest earned.

Operations of the Research Fund for the calendar year 1938 have been detailed in a separate report rendered to you.

OPERATIONS

There is attached hereto Statements of Income and Expenses for the calendar year 1938 showing an excess of Expenses over Income from Society activities of $8,300.27 and a net income of $8,252.91 from GUIDE Operations. In the preparation of these statements 30% of the Salaries and Office expenses have been allocated to GUIDE Operations.

Respectfully submitted,

TUSA & LA BELLA,
(Signed) Frank G. Tusa,
Certified Public Accountants.

BALANCE SHEET

AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS
New York, N. Y.
December 31, 1938

ASSETS

SOCIETY			
CASH			
On deposit	$42,517.50		
On hand	100.00		
		$42,617.50	
In closed bank		418.97	
			$43,036.47
RESERVE FUNDS			
On deposit		$ 1,587.18	
On hand for deposit		125.82	
			1,713.00
INVESTMENTS (AT COST)			
Securities (Market value $19,284.58)		$19,171.14	
Add: Accrued interest		61.46	
			19,232.60
ACCOUNTS RECEIVABLE			
Membership dues	$13,846.63		
Less: Reserve for doubtful	8,105.85		
		$ 5,740.78	
Advertisers and sundry debtors	$32,030.15		
Less: Reserve for doubtful	1,462.62		
		30,567.53	
			36,308.31
INVENTORIES			
TRANSACTIONS		$ 3,231.25	
Emblems and certificate frames		69.10	
Stationery		226.36	
			3,526.71
PERMANENT			
Library		$ 300.00	
Furniture and fixtures	$ 6,979.90		
Less: Reserve for depreciation	5,206.59		
		1,773.31	
			2,073.31
DEFERRED CHARGES			
Unexpired insurance premiums		$ 187.50	
Meeting expenses		528.60	
			716.10
			$106,606.50
SPECIFIC FUNDS			
ENDOWMENT FUND			
Cash on deposit		$13,273.44	
Securities at cost (Market value $7,942.25)		$11,918.65	
Add: Accrued interest		111.35	
		12,030.00	
			25,303.44
F. PAUL ANDERSON AWARD FUND			
Cash on deposit			1,188.28
RESEARCH FUND			
ENDOWMENT FUND			
Cash on deposit		$ 517.12	
Cash in closed bank		167.78	
		$ 684.90	
UNRESTRICTED FUNDS			
Cash on deposit		$16,187.55	
Cash on hand		45.47	
Cash on hand for deposit		1,430.16	
		17,663.18	
			18,348.08
			$151,446.30

LIABILITIES AND CAPITAL

SOCIETY			
ACCOUNTS PAYABLE		$23,158.82	
PAYABLE TO RESEARCH FUND			
On dues as and when collected		3,796.31	
ACCRUED ACCOUNTS			
Compensation—Secretary and staff		2,685.43	
DEFERRED INCOME			
Prepaid dues—Members	$ 549.80		
Prepaid dues—Proposed members	273.13		
		822.93	
TOTAL LIABILITIES		$30,463.49	
GENERAL FUND			
Society		76,143.01	
			$106,606.50
SPECIFIC FUNDS			
ENDOWMENT FUND			
Principal		$24,063.28	
Unexpended income		1,240.16	
			25,303.44

F. PAUL ANDERSON AWARD FUND			
Principal		$ 1,000.00	
Unexpended income		188.28	1,188.28
RESEARCH FUND			
ENDOWMENT FUND			
Principal	$ 600.00		
Unexpended income	84.90		
		$ 684.90	
UNRESTRICTED FUND			
Balance—January 1, 1938	$11,606.38		
Excess of expenses over income calendar year ended December 31, 1938	6,056.80		
		17,663.18	
			18,348.08
			$151,446.30

NOTE "A": This Balance Sheet is subject to the comments contained in the letter attached to and forming a part of this report.

BUDGET COMPARISON

AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS
New York, N. Y.

For the Calendar Year Ended December 31, 1938

	Actual	Budget Provision	Increases Decreases
Income:			
Membership dues and Initiation fees	$ 29,106.32	$ 28,000.00	$ 1,106.32
Editorial Contract	15,343.04	14,500.00	843.04
Profit—Emblem and certificate frames	98.39	100.00	1.61
Profit—Reprints and books	368.61	300.00	68.61
Sales of TRANSACTIONS	504.62	500.00	4.62
Interest—Bank	735.79	700.00	35.79
Interest—Securities	305.00	300.00	5.00
GUIDE—Advertising	27,690.66	32,200.00	4,509.34
GUIDE—Copy sales	26,195.44	30,000.00	3,804.56
	$100,347.87	$106,600.00	$ 6,252.13
Expenses:			
General Society Activities:			
Meetings	$ 1,795.63	$ 2,000.00	$ 204.37
Chapter allowances	593.24	1,000.00	406.76
Promotional	4,290.70	3,600.00	690.70
Speakers Bureau	1,369.88	2,000.00	630.12
Subscriptions	6,203.85	6,000.00	203.85
Postage	1,850.02	2,500.00	649.98
Rent	3,271.25	4,000.00	728.75
TRANSACTIONS	4,524.42	3,500.00	1,024.42
Codes	218.73	800.00	581.27
Salaries	16,643.00	17,700.00	1,057.00
General printing	965.12	800.00	165.12
Membership certificates and emblems	261.00	600.00	339.00
Travel—President	1,149.25	1,800.00	650.75
Travel—Secretary	1,437.20	1,500.00	62.80
Council and Chapter Delegates travel	3,711.28	4,500.00	788.72
Bank charges	74.57	100.00	25.43
Multigraphing	613.45	600.00	13.45
Telephone	754.61	600.00	154.61
Telegraph	418.85	300.00	118.85
Professional services	400.00	500.00	100.00
General office expenses	675.38	600.00	75.38
Office supplies	356.50	500.00	143.50
Furniture and fixtures	923.24	1,000.00	76.76
Reserve for additional compensation	2,685.43	2,500.00	185.43
Special appropriation	100.00	1,100.00	1,000.00
	$ 55,286.60	$ 60,100.00	$ 4,813.40
Cost of GUIDE:			
Editorial and advertising salaries	6,550.00	7,200.00	650.00
Committee travel	231.36	800.00	568.64
Printing and binding	15,630.94	20,000.00	4,369.06
Mailing	1,680.00	2,500.00	820.00
Paper	3,483.09	4,500.00	1,016.91
Cuts	436.45	500.00	63.55
Advertising sales promotion	1,643.12	2,000.00	356.88
Copy sales	10,006.70	7,500.00	2,506.70
Yearbook	1,327.22	1,500.00	172.78
	40,988.88	46,500.00	5,511.12
	$ 96,275.48	$106,600.00	$10,324.52
Unbudgeted Appropriations—Research fund	5,000.00	.....	5,000.00
	$101,275.48	$106,600.00	$ 5,324.52

At the conclusion of the report, on motion of Mr. McIntire, seconded by W. L. Fleisher, New York, N. Y., it was voted that the report of the Finance Committee be adopted.

The report of the Membership Committee was presented by R. C. Bolsinger, Philadelphia, Pa., chairman.

Report of Membership Committee

Due to conditions, your committee has not shown as large an increase as desired in membership for the year 1938.

Although membership is the greatest asset of the Society, we have suggested to the various Chapter membership chairmen that numbers is not our chief aim; character and interest are important.

Potential new membership in the South has been pioneered by W. L. Fleisher in the Carolinas and F. E. Giesecke in Texas, which now has two Chapters—the South Texas Chapter at Houston and the North Texas Chapter at Dallas.

We should encourage Pacific Coast activity from British Columbia to lower California by having Council or Society meetings in this section.

It is suggested by this committee that the new membership committee give consideration to the idea of appointing zone chairmen to work with the Council Membership Committee so that closer cooperation can be given the outlying Chapter membership chairmen.

During the year 1938, 389 members were elected to the various grades and the present membership status of the Society is as follows:

Honorary Members	2
Presidential Members	21
Life Members	55
Members	1614
Associate Members	780
Junior Members	471
Student Members	59
Total	3002

In closing we want to express our appreciation for the assistance of A. V. Hutchinson and the staff at the Headquarters office in carrying out the work of the Committee.

Respectfully submitted,

MEMBERSHIP COMMITTEE
R. C. BOLSINGER, *Chairman.*
W. A. RUSSELL
G. L. WIGGS

President Gurney announced that 1939 marked the 20th anniversary of the establishment of the Society's Research Laboratory and he paid tribute to the work of the devoted men who had carried on this important Society project. He called upon the men present who had served as chairmen of the Committee on Research to arise and be introduced. The following responded: G. W. Barr, Philadelphia; J. I. Lyle, Syracuse; W. H. Driscoll, Syracuse; F. B. Rowley, Minneapolis; C. V. Haynes, Ardmore, Pa.; G. L. Larson, Madison, Wis.; John Howatt, Chicago; A. P. Kratz, Urbana, Ill., and W. A. Danielson, Fort Knox, Ky. Letters and telegrams from those who could not be present were read from Thornton Lewis and F. R. Still, New York; E. E. McNair, St. Petersburg, Fla.; Perry West, Lexington, Ky.; S. R. Lewis, Chicago; and H. P. Gant, Philadelphia.

Mr. Fleisher, chairman of the Committee on Research, was introduced and gave an abstract of the committee's report. (Complete report published in February, 1939, ASHVE JOURNAL SECTION, *Heating, Piping and Air Conditioning.*) At the conclusion of the report, on motion of Mr. Fleisher, seconded by Percy Nicholls, Pitts-

burgh, Pa., it was moved that the report of the Committee on Research be adopted.

The first research paper, entitled Frictional Resistance to the Flow of Air in Straight Ducts by F. C. Houghten, J. B. Schmieler, John Zalovcik and Nicholas Ivanovic, was introduced by J. H. Van Alsburg, Chicago, Ill., chairman of the Technical Advisory Committee on Air Distribution and Air Friction. (Complete paper published in December, 1938, ASHVE JOURNAL SECTION, *Heating, Piping and Air Conditioning*). He outlined the procedure of the committee in reviewing all published literature and reliable research data on the subject of air flow in ducts and said that further work was to be carried on at the Society's Research Laboratory and in cooperating institutions. It was the aim of the committee to obtain sufficient data to establish a standard method of sizing ducts for all types of heating, ventilating and air conditioning service. One of the authors, Mr. Schmieler, Pittsburgh, Pa., presented an abstract of the paper.

President Gurney invited discussion of the paper and F. R. Bichowsky, Ann Arbor, Mich., inquired about the application of the Fanning formula to the experimental work and F. C. Houghten, Pittsburgh, Pa., replied that the constants in the formula were changed only for the research data presented, so that data for the 8-in. duct could be properly extrapolated to fit the 4-in. and 24-in. ducts.

The paper, Air Conditioning in Industry, by W. L. Fleisher, A. E. Stacey, Jr., F. C. Houghten and M. B. Ferderber, was introduced by Mr. Fleisher. (Complete paper to be published in ASHVE JOURNAL SECTION, *Heating, Piping and Air Conditioning*. Part 1 in February, Part 2 in March, 1939.) Mr. Stacey, New York, N. Y., gave the engineering calculations and Dr. Ferderber, Pittsburgh, Pa., presented the physiological aspects of the study. When President Gurney invited discussion, questions were asked by W. H. Carrier, Syracuse, N. Y., about the effect of clothing on subjects and Prof. C.-E. A. Winslow, New Haven, Conn., inquired whether the leucocyte count was affected by the changes in blood volume. W. B. Hodge, Charlotte, N. C., asked whether consideration had been given to conditions in the textile industries and Prof. James Holt, Cambridge, Mass., inquired about the effect of environmental conditions on northern workers who went south. Lt. Com. R. M. Watt, Jr., Washington, D. C., asked if the work had developed information bearing on the problem of ship ventilation. The closing discussion in answer to the questions was given by Mr. Houghten, director of the Research Laboratory.

The report of the tellers was given by the secretary, Mr. Hutchinson, as follows:

Report of Tellers of Election

Ballot for Officers

	For
President—J. F. McIntire	692
First Vice-President—F. E. Giesecke	691
Second Vice-President—W. L. Fleisher	675
Treasurer—M. F. Blankin	692

Scattering votes were recorded for nine other members.

Members of the Council—Three-Year Term

E. K. Campbell	688
S. H. Downs	690
A. J. Offner	689
G. L. Tuve	690

Scattered votes were recorded for five other members.

Total ballots counted	737
Ballots invalid	36

Ballot for Committee on Research

Three-Year Term

R. E. Daly	691
W. A. Danielson	690
H. J. Rose	689
C. Tasker	691
C.-E. A. Winslow	689

Scattering votes were recorded for five other members.

Total ballots counted	737
Ballots invalid	36

BOARD OF TELLERS
A. C. BUENSOD, *Chairman*
C. S. PABST
E. N. SANBERN.

Report of Tellers

Ballot for Amendment to Constitution and By-Laws Article C-V, Section 1

Number of ballots *For*	611
Number of ballots *Against*	23
Total number of ballots	634
Illegal ballots	29

BOARD OF TELLERS
H. G. MEINKE, *Chairman*
W. E. HEIBEL
E. N. SANBERN.

SECOND SESSION

Tuesday, January 24, 1939, 9:30 A. M.

President Gurney called the meeting to order and introduced Professor Winslow to give the paper, Recent Advances in Physiological Knowledge and Their Bearing on Ventilation Practice. (Complete paper published in January, 1939 ASHVE JOURNAL SECTION, *Heating, Piping and Air Conditioning.*)

With 2nd Vice-Pres. F. E. Giesecke, College Station, Tex., in the chair, the author of the second paper, Dr. R. W. Keeton, Chicago, Ill., was introduced and presented an abstract of Cardiac Output, Peripheral Blood Flow, and Blood Volume Changes in Normal Individuals Subjected to Varying Environmental Temperatures by F. K. Hick, R. W. Keeton, Nathaniel Glickman and H. C. Wall. (Complete paper published in January, 1939, ASHVE JOURNAL SECTION, *Heating, Piping and Air Conditioning.*) A written discussion by Dr. E. F. DuBois, New York, N. Y., was read by John James, New York. Comments were made by Mr. Fleisher and Professor Winslow, and the reply to the questions asked in discussion was given by Dr. Hick, Chicago, Ill.

Chairman Giesecke introduced Dr. Charles Sheard, director, Division of Physics and Biophysical Research, Mayo Clinic, Rochester, Minn., who presented the paper, The Role of the Extremities in the Dissipation of Heat from the Body in Various Atmospheric and Physiological Conditions, by Charles Sheard, Marvin M. D. Williams, Grace M. Roth and Bayard T. Horton. (Complete paper to be published in ASHVE JOURNAL SECTION, *Heating, Piping and Air Conditioning.*) In the discussion Dr. Ferderber complimented the authors and cited some results of observations made in Pittsburgh. Dr. Sheard then gave an abstract of the paper, Skin Temperatures of the Extremities and Effective Temperature, by Charles Sheard, Marvin M. D. Williams and Bayard T. Horton. (Complete paper to be pub-

lished in ASHVE JOURNAL SECTION, *Heating, Piping and Air Conditioning.*)

Chairman Giesecke called for the final paper of the session, entitled Air Conditioning Requirements of an Operating Room and Recovery Ward, by F. C. Houghten and W. Leigh Cook, Jr., which was presented by Dr. Cook, Pittsburgh, Pa., in abstract. (Complete paper to be published in ASHVE JOURNAL SECTION, *Heating, Piping and Air Conditioning.*) Dr. B. Z. Cashman, Pittsburgh, Pa., gave his observations as a surgeon regarding the comfort and physiological reactions of the staff and patients in operating rooms. Dr. T. L. Hazlett, Pittsburgh, Pa., Dr. Ferderber and Dr. Keeton commented on the report and Dr. Sheard spoke of the most desirable temperatures and humidities for recovery wards. Col. W. A. Danielson, Fort Knox, Ky., spoke of the importance of air circulation and Mr. Houghten described the air supply and method of distribution.

THIRD SESSION

Tuesday, January 24, 1939, 2:00 P. M.

The third session of the meeting was called to order at 2:00 p. m. by 1st Vice-President McIntire, who introduced J. D. Edwards, New Kensington, Pa., coauthor of the paper, Some Reflection and Radiation Characteristics of Aluminum by C. S. Taylor and J. D. Edwards. (Complete paper published in January, 1939, ASHVE JOURNAL SECTION, *Heating, Piping and Air Conditioning.*) Written discussions of the paper were presented by Mr. James from P. D. Close, Chicago, Ill., Prof. E. A. Allcut, Toronto, Ont., and P. F. McDermott, Manville, N. J. Prof. F. B. Rowley, Minneapolis, Minn., commented on the need for obtaining practical emissivity coefficients and the need for studies of other materials. Colonel Danielson asked about the durability of aluminum paints and foils. Mr. Edwards replied to the questions asked during the discussion.

Mr. McIntire announced that the paper, A Study of the Heat Requirements of a Single-Glazed Test House and a Double-Glazed Test House by M. L. Carr, R. A. Miller, Leighton Orr and David Shore, would be presented by one of the authors, Mr. Orr. (Complete paper published in November, 1938, ASHVE JOURNAL SECTION, *Heating, Piping and Air Conditioning.*) At the conclusion of the presentation of the paper, Mr. James read a written discussion by Mr. Carr, Pittsburgh, Pa. Questions were asked by W. C. Randall, Detroit, Mich., W. R. Rhoton, Cleveland, Ohio, Mr. Edwards, and R. A. Miller, Pittsburgh, Pa., and discussions were closed by Mr. Orr.

Second Vice-President Giesecke assumed the chair and called for the presentation of the paper, Heat Transfer in Storage Water Heaters by D. W. Nelson and A. A. Rosenberg. (Complete paper to be published in ASHVE JOURNAL SECTION, *Heating, Piping and Air Conditioning.*) Mr. Rosenberg, Pittsburgh, Pa., gave an abstract of the paper. At the conclusion of the presentation, Mr. James read a discussion by Prof. G. L. Tuve, Cleveland, Ohio. Colonel Danielson, E. W. Rietz, Chicago, L. P. Saunders, Lockport, N. Y., and H. M. Nobis, East Cleveland, Ohio, asked questions which were answered by Professor Nelson, Madison, Wis.

First Vice-President McIntire returned to the chair and introduced Professor Rowley who presented the paper, Condensation of Moisture and Its Relation to Building Construction and Operation by F. B. Rowley, A. B. Algren and C. E. Lund. (Complete paper published in January, 1939, ASHVE JOURNAL SECTION, *Heating, Piping and Air Conditioning.*) In the discussion R. A. Miller discussed some of the methods of preventing penetration of water vapor. Prof. W. T. Miller, Lafayette, Ind. described the study of condensation in test houses at Purdue University.

Immediately after the session the technicolor film, Steel—Man's Servant, was shown.

FOURTH SESSION

Wednesday, January 25, 1939, 9:30 A. M.

First Vice-President McIntire called the meeting to order and announced that the registration exceeded 500. He introduced Colonel Danielson, who gave his paper, Responsibility of the ASHVE Towards the Solid Fuel Industry. (Complete paper published in February, 1939, ASHVE JOURNAL SECTION, *Heating, Piping and Air Conditioning.*)

The next paper, Selection of Solid Fuels from the Viewpoint of the Small Consumer, was presented in abstract by the author, Percy Nicholls, Pittsburgh, Pa. (Complete paper published in February, 1939, ASHVE JOURNAL SECTION, *Heating, Piping and Air Conditioning.*) Comments on the paper were given by Tom Marsh, Chicago, Ill., H. J. Rose, Pittsburgh, Pa., J. D. Doherty, Pittsburgh, E. K. Campbell, Kansas City, Mo., and Prof. A. P. Kratz, Urbana, Ill. Detailed replies to the questions asked were given by Mr. Nicholls.

The paper, Small Stokers, by P. A. Mulcey and R. A. Sherman, was presented by Mr. Sherman, Columbus, Ohio, in abstract. Comments were made by Colonel Danielson, W. C. Kelly, Toronto, L. P. Hynes, Philadelphia, Pa., and T. H. Urdahl, Washington, D. C. Replies to the questions were given by Messrs. Mulcey and Sherman.

Chairman McIntire introduced Prof. S. Konzo, Urbana, Ill., to give the concluding paper of the session, Performance of Stoker-Fired and Hand-Fired Warm-Air Furnaces in the Research Residence, by A. P. Kratz, S. Konzo and R. B. Engdahl. (Complete paper published in November, 1938, ASHVE JOURNAL SECTION, *Heating, Piping and Air Conditioning.*) With Professor Giesecke in the chair, a written discussion by C. J. Scanlan, Bloomington, Ill., was presented by title and additional comments were offered by A. J. Johnson, Primos, Pa., after which Professor Kratz replied for the authors.

FIFTH SESSION

Wednesday, January 25, 1939, 2:00 P. M.

The fifth technical session of the 45th Annual Meeting was called to order by Professor Giesecke, 2nd vice-president, and the paper, Smoke Abatement—Where to Draw the Line, by H. B. Meller, was read by Mr. James. (Complete paper published in March, 1939, ASHVE JOURNAL SECTION, *Heating, Piping and Air Conditioning.*)

An abstract of the paper, Smoke Producing Tendencies in Coals of Various Ranks by H. J. Rose and F. P. Lasseter, was given by Mr. Rose. (Complete paper pub-

lished in February, 1939, ASHVE JOURNAL SECTION, *Heating, Piping and Air Conditioning.*) Some questions were asked by Mr. Kelly, and Mr. Weitzel, and replies were given by Mr. Rose.

The paper, Air Filter Performance as Affected by Low Rate of Dust Feed, Various Types of Carbon, and Dust Particle Size and Density by F. B. Rowley and R. C. Jordan, was presented in abstract by Professor Rowley. (Complete paper to be published in ASHVE JOURNAL SECTION, *Heating, Piping and Air Conditioning.*) Questions were asked by W. J. Ottinger, Cleveland, Ohio; Mr. May, G. W. Penney, East Pittsburgh, Pa.; E. C. Evans, Syracuse, N. Y.; H. C. Murphy, Louisville, Ky.; R. S. Dill, Washington, D. C.; J. H. Ferguson, Cleveland, Ohio; Prof. Axel Marin, Ann Arbor, Mich.; J. W. Kreuttner, New York, N. Y.; Mr. Rose and J. E. Ryan, Schenectady, N. Y. A written discussion by Arthur Nutting, Louisville, Ky., was read by Mr. James. A reply to the questions was made by Professor Rowley.

SIXTH SESSION

Thursday, January 26, 1939, 9:30 A. M.

President Gurney opened the sixth session at 9:30 a. m. and requested Mr. Ryan to present the paper, The Effect of Heat Storage and the Variation in Outdoor Temperature and Solar Intensity on the Heat Transfer Through Walls by J. S. Alford, J. E. Ryan and F. O. Urban. (Complete paper to be published in ASHVE JOURNAL SECTION, *Heating, Piping and Air Conditioning.*) Professor Giesecke expressed the wish that the authors continue their work on non-homogeneous walls. J. H. Walker, Detroit, Mich., said that the Committee on Research believed that calibration of heat gain through walls should be verified by actual test and described a program to be carried out by the Research Laboratory.

New Officers Installed

Professor Rowley, past president of the Society, conducted the installation, assisted by F. C. McIntosh and Prof. C. M. Humphreys, Pittsburgh, Pa. President-elect J. F. McIntire expressed his appreciation of the honor of being president of the Society. The other officers installed were Prof. F. E. Giesecke, 1st vice-president; W. L. Fleisher, 2nd vice-president, and M. F. Blankin, Philadelphia, Pa., treasurer. The newly elected Council members were introduced, Messrs. E. K. Campbell, S. H. Downs, Kalamazoo, Mich.; A. J. Offner, New York, N. Y., and G. L. Tuve.

President McIntire introduced J. C. Albright, New York, N. Y., who presented his paper, Analysis of Summer Weather Data in the United States. (Complete paper published in March, 1939, ASHVE JOURNAL SECTION, *Heating, Piping and Air Conditioning.*) Comments were made by Mr. Fleisher, Mr. Ryan, G. L. Wiggs, Montreal, Can., and Mr. Urdahl.

The next paper, Application of Summer Weather Data in Design, was presented by the author, John Everetts, Jr., Dayton, Ohio. (Complete paper to be published in ASHVE JOURNAL SECTION, *Heating, Piping and Air Conditioning*).

Dr. Giesecke presented his paper, The Flow of Heat Through Walls. (Complete paper published in December, 1938, ASHVE JOURNAL SECTION, *Heating, Piping and Air Conditioning.*) Comments were made by Mr. Ryan.

The final paper of the session was given by A. J. Rummel, San Antonio, Tex., entitled Reactions of Office Workers to Air Conditioning in South Texas, by A. J. Rummel, F. E. Giesecke, W. H. Badgett and A. T. Moses. (Complete paper to be published in ASHVE JOURNAL SECTION, *Heating, Piping and Air Conditioning.*)

President McIntire called for unfinished business and the secretary was requested to read the proposed amendment to the By-Laws relating to initiation fees and dues. The amendments to Article B-IV, Sections 1, 2, 5 and 7 were read. On motion of Mr. Fleisher, seconded by Professor Rowley, it was voted to adopt the amendment to Article B-IV, Section 1.

Article B-IV, Section 1—The admission fee of Members, Associate Members, Junior Members and Student Members shall be as determined by the Council until 1940 and thereafter the admission fee of Members and Associate Members shall be fifteen dollars ($15.00); of Junior Members five dollars ($5.00); and of Student Members two dollars ($2.00). Admission fee must accompany application.

To be amended as follows:

The admission fee of Members, Associate Members, Junior Members and Student Members shall be as determined by the Council until 1942 and thereafter the admission fee of Members and Associate Members shall be fifteen dollars ($15.00); of Junior Members five dollars ($5.00); and of Student Members two dollars ($2.00). Admission fee must accompany application.

On motion of Professor Rowley, seconded by Mr. Fleisher, the following amendment was unanimously adopted, Article B-IV, Section 2.

Article B-IV, Section 2—The annual dues of Members, Associate Members, Junior Members and Student Members shall be as determined by the Council until 1940 and thereafter the dues of Members and Associate Members shall be twenty-five dollars ($25.00); of Junior Members twelve dollars ($12.00); and of Student Members five dollars ($5.00).

To be amended as follows:

The annual dues of Members, Associate Members, Junior Members and Student Members shall be as determined by the Council until 1942 and thereafter the dues of Members and Associate Members shall be twenty-five dollars ($25.00); of Junior Members twelve dollars ($12.00); and of Student Members five dollars ($5.00).

After some discussion by C. S. Leopold, Philadelphia, Pa., Professor Rowley, R. A. Miller, Messrs. Gurney, Fleisher and Offner, on motion of J. J. Aeberly, Chicago, Ill., seconded by Professor Giesecke, it was voted to reject the amendment to Article B-IV, Section 5. On motion of Professor Rowley, seconded by Mr. Aeberly, it was voted to reject the amendment to Article B-IV, Section 7. President McIntire called for discussion of new business and Mr. Gurney offered the following resolution, seconded by L. T. Avery, Cleveland, Ohio:

That a committee shall be appointed for the purpose of studying the entire question of the selection of council members and officers in order that due representation shall be given to the important number of society members who have no chapter affiliations. I propose that this committee shall consist of the chairman of the Advisory Council, the president, the chairman of the Constitution and By-Laws Committee, the chairman of the Nominating Committee, and two members at large to be nominated now from the floor of this meeting.

Comments were made by Messrs. Offner, Campbell,

Wiggs, Downs, W. A. Russell, Waterbury, Conn.; Tom Brown, Chicago; C. H. Randolph, Milwaukee, Wis., and N. D. Adams, Rochester, Minn.

The resoluton was unanimously adopted.

President McIntire invited nominations from the floor for the election of two members to serve on a special committee authorized by vote of the meeting. Professor Rowley nominated N. D. Adams; Prof. C. M. Humphreys, Pittsburgh, Pa., nominated E. K. Campbell; J. H. Ferguson, Cleveland, Ohio, nominated L. T. Avery; Mr. McIntosh nominated W. T. Jones, Boston, Mass.; Mr. Brown nominated W. A. Russell. These nominations were properly seconded and on motion of Mr. Gurney, seconded by Mr. Wiggs, it was voted that nominations be closed and that a vote by ballot be recorded by the secretary of the Society.

On motion of Mr. Gurney, seconded by Mr. Miller, it was voted that the president of the Society or his appointee act as chairman of the special committee.

Mr. Gurney then offered a petition for a revision of the By-Laws signed by 10 members, which under Article B-XVI of the By-Laws would be submitted to all members at least 30 days in advance of the next Society meeting.

Resolutions

H. M. Hendrickson, Los Angeles, Calif., offered the following resolutions:

Whereas, the 45th Annual Meeting of the American Society of Heating and Ventilating Engineers has been a great success, it is fitting that we should express our appreciation and thanks:

To the Pittsburgh Chapter, for the excellent manner in which the arrangements for this meeting were handled;

To the members of the committees of the Pittsburgh Chapter, for the excellent management of the meeting and their friendly hospitality.

To the City of Pittsburgh, its citizens and its officials, for their hospitality;

To the William Penn Hotel, its employees, and management, for the excellent manner in which they have handled arrangements and the service which they have given us during our stay here;

To the Pittsburgh Convention and Tourist Bureau for their assistance and interest;

To the speakers and the authors of the many technical papers and for their excellent presentation of the material that has been so valuable to us here;

To the newspapers and the trade journals for the excellent publicity which they have given this meeting;

To the personnel of the Headquarters office staff, for the manner in which they have helped us and made us feel at home;

To the national officers of the Society for the smooth manner in which all the meetings and events were handled.

And last, but not least, we thank the ladies for coming here and for their gracious presence, which we appreciate.

The motion was seconded by W. H. Badgett, College Station, Tex.

Mr. Miller, president of the Pittsburgh Chapter, responded to the resolution and thanked the members present for their attendance at the meeting, for the cooperation given by everyone, and said that the success of the 45th Annual Meeting of the Society had been due to the complete and enthusiastic acceptance of both the technical and entertainment programs by the visiting members.

The meeting then adjourned.

Carnegie Museum

Chapter Delegates Conference

The Second Conference of Chapter delegates was held at the William Penn Hotel on Monday morning, January 23. Pres. E. Holt Gurney presided and among those attending were: T. T. Tucker, Atlanta; E. B. Royer, Cincinnati, G. M. Simonson, Golden Gate; J. R. Vernon, Illinois; W. R. White, Iowa-Nebraska; C. A. Flarsheim, Kansas City; William Worton, Manitoba; James Holt, Massachusetts; F. J. Linsenmeyer, Michigan; W. W. Bradfield, Western Michigan; J. E. Swenson, Minnesota; F. J. Friedman, Montreal; H. G. Meinke, New York; J. J. Landers, Western New York; C. M. H. Kaercher, Northern Ohio; E. W. Gray, Oklahoma; H. R. Roth, Ontario; R. O. Wesley, Pacific Northwest; H. H. Erickson, Philadelphia; C. M. Humphreys, Pittsburgh; E. E. Carlson, St. Louis; H. M. Hendrickson, Southern California; W. H. Badgett, South Texas; S. P. Eagleton, Washington, D. C.; H. C. Frentzel, Wisconsin; T. H. Anspacher, North Texas. Others present were Tom Brown, Chicago, G. L. Wiggs, Montreal, E. F. Dawson, Oklahoma City, R. C. Bolsinger, Philadelphia, W. A. Russell, Waterbury, Conn., W. G. Boales, Detroit, and L. H. Laffoley, Montreal.

Mr. Bolsinger gave a resumé of the Society's membership and Mr. Russell gave a report of the activities of the Speakers Bureau. Plans for the Semi-Annual Meeting of the Society at Mackinac Island July 4 to 6, 1939 were outlined by Mr. Boales.

Among the subjects of discussion were the visits of national officers to Chapters; the possibility of zone meetings; the sponsorship of codes by Chapters; the combining of local and national dues; increasing the allotment of speakers; local memberships and visitors at Chapter meetings; handling membership applications; what can the national Society do to inform incoming officers of Chapters of their relationship and duties toward the Society; the problem of properly training officers for Chapter service; and model registration laws for engineers.

Mellon Institute

Pittsburgh Provides Delightful Entertainment

VISITING members, guests, and ladies, who attended the 45th Annual Meeting of the Society, took up the program of entertainment which was planned by the Pittsburgh Chapter with a spirit and zest which assured the success of the various scheduled events.

Partying began early when on Sunday, January 22, an informal reception was held which started at 2:00 p.m. and continued from 7:00 to 10:00 p.m. in the evening. At 3:00 p.m. Pres. E. Holt Gurney was guest speaker on the Armco Hour, broadcast over radio station KDKA at Pittsburgh and the NBC Blue Network. Arrangements were made to receive the broadcast in the Pittsburgh Chapter Room of the William Penn Hotel, where the reception was held.

On Monday, January 23, following the first technical session, a welcome luncheon for members, guests, and ladies was served in the Urban Room of the hotel to 200 members, guests and ladies. R. A. Miller, president of the Pittsburgh Chapter, presided at the speakers' table. Greetings were given by Mayor C. D. Scully of Pittsburgh, to which Pres. E. Holt Gurney responded. An address by C. E. Mayette, New York, consulting engineer, on The Position of the Consulting Engineer in the U. S. Housing Problem was featured.

At 3:00 p.m. the ladies had tea in the Forum Room and at 5:00 p.m. many gathered in the chapter room for a social hour.

A Jamboree Dinner was held Monday evening at 7:00 p.m. in the Chatterbox. R. J. J. Tennant was an able master of ceremonies and introduced the numbers of the floor show provided by Pittsburgh Chapter. Music was played for dancing by Little Jackie Heller and his orchestra.

On Tuesday, January 24, a ladies' bridge luncheon in the Cardinal Room was attended by 48. Contract bridge was played by 32 and auction bridge and Chinese checkers each had four devotees. Mrs. R. B. Stanger was chairman and among those who received awards for their skill were Mrs. G. P. Ellis, Mrs. Leighton Orr, Mrs. L. E. Seeley, Mrs. J. F. Collins, Jr., Mrs. H. A. Canon, Mrs. H. L. Moore, Mrs. J. D. Edwards, Mrs. C. A. McMunn, Jr., Mrs. H. A. Beighel, Mrs. C. M. Kaercher, Mrs. M. F. Blankin and Mrs. P. J. Heenan.

At 5:00 p.m. a special broadcast from station KDKA was arranged by T. F. Rockwell, secretary of Pittsburgh Chapter, on the Relationship of Atmospheric Environment to Comfort and Health. Those who took part in this radio interview were President Gurney, W. L. Fleisher, Prof. C.-E. A. Winslow, Dr. Charles Sheard and Mr. Sutherland, KDKA announcer.

Immediately following the close of the third technical session, a technicolor film entitled Steel—Man's Servant, was shown at 5:15 p.m. and dramatically told the story of steel making in the plants of Carnegie-Illinois Steel Corp. Edwin C. Hill was the narrator and the musical score was directed by Robert Armbruster.

The past presidents dined at 6:30 p.m. and those who enjoyed this annual reunion were Homer Addams, F. B. Rowley, John Howatt, W. T. Jones, J. F. Hale, G. L. Larson, Thornton Lewis, W. H. Carrier, H. P. Gant, C. V. Haynes and W. H. Driscoll.

A Night in Bavaria was the title of a lively evening in the Bavarian Room of the William Penn Hotel, where a special supper for Society members and guests was served. The fun began at 9:30 p.m. and entertainment was provided by the original Bavarian Troupe, assisted by those of the ASHVE group. The Committee on Arrangements had provided Tyrolean hats with large quills of various colors and canes which added to the gaiety.

Wednesday morning at 10:00 a.m. the ladies were conducted on a tour which took them to East Liberty Presbyterian Church and the Schenley District Civic Center, following which they were the guests of the Pittsburgh Chapter at luncheon.

This year one of the outstanding events of the meeting took place at the Society's annual banquet on Wednesday night in the grand ballroom, when Thornton Lewis presented the F. Paul Anderson Medal to Prof. F. B. Rowley. This award was created by Mr. Lewis in tribute to the late Dean Anderson and has been given on only two previous occasions—in 1932 to W. H. Carrier and in 1936 to Dr. A. C. Willard. It was awarded to Professor Rowley for his attainments in the field of thermal research and their influence upon the arts of heating, ventilating and air conditioning and for his outstanding services to the Society as a member and officer. Upon receiving the medal, Professor Rowley expressed his appreciation for this award. The past president's emblem was presented to President Gurney by W. T. Jones. Prof. E. O. Eastwood, who was toastmaster, introduced Dr. John Gabbert Bowman, chancellor of the University of Pittsburgh. Dr. Bowman gave an inspiring address on the desirable balance to be obtained in life between an appreciation of culture and beauty and scientific knowledge. Mr. Gurney spoke briefly of his pleasure at having served the Society as president and introduced J. F. McIntire, president elect, who responded. Dancing followed the banquet in the Urban Room and the music was by Joey Sims and his orchestra.

Thursday morning, January 26, the ladies spent shopping in the Pittsburgh stores and at 1:00 p.m. many members were taken on inspection trips to the ASHVE Research Laboratory, the New Irvin Works of the Carnegie-Illinois Steel Co., the Spang-Chalfant new pipe mill, and the Heinz factory.

Members and guests left Pittsburgh with a feeling that they had participated in a very enjoyable and successful meeting and offered their thanks and congratulations to the following Committee on Arrangements:

45th Annual Meeting

Committee on Arrangements

R. A. Miller, President Pittsburgh Chapter; John F. Collins, Jr., *General Chairman;* Arthur McGonagle, *Honorary Chairman;* Clark M. Humphreys, *First Vice-Chairman;* Fabian C. McIntosh, *Second Vice-Chairman.*

Finance Committee—Maurice L. Carr, *Chairman;* Leon S. Maehling; E. H. Riesmeyer, Jr.; R. J. J. Tennant; Robert A. Miller; Edward C. Smyers.

Publicity Committee—Theodore F. Rockwell, *Chairman;* Frank B. Mahon; Ralph B. Stanger.

Attendance Committee—Arthur F. Nass, *Chairman.*

Reception Committee—J. Earl Frazier, *Chairman;* Mrs. Herbert A. Canon, *Vice-Chairman;* H. A. Beighel; H. A. Biber; G. C. Blackmore; Roy Brauer; E. M. Burkhart; G. M. Comstock; R. P. Dickinson, Jr.; R. W. Dickson, Jr.; T. M. Dugan; J. E. Eckstein; L. C. Eils; G. P. Ellis; F. H. Gallagher; C. B. Hathaway; F. H. Hecht; R. H. Heilman; F. C. Houghten; E. H. Hyde; P. M. Kimmel; B. D. Landes; Walter Lowe; F. E. Lynn; J. E. Mueller; Percy Nicholls; H. E. Park; G. W. Penney; John Proie; I. G. Reed; Van A. Reed, Jr.; E. S. Scanlon; E. T. Selig, Jr.; L. T. Sherwood; Charles Sonneborn; W. W. Stevenson; F. A. Sutherland; G. O. Weddell; Mrs. H. A. Biber; Mrs. G. P. Ellis; Mrs. J. Earl Frazier; Mrs. H. E. Lore; Mrs. D. W. Loucks; Mrs. F. B. Mahon; Mrs. J. E. McLean; Mrs. H. Lee Moore; Mrs. Wm. H. Reed, III; Mrs. E. C. Smyers; Mrs. P. C. Strauch; Mrs. R. J. J. Tennant; Mrs. G. G. Waters.

Technical Sessions Committee—Paul A. Edwards, *Chairman;* Leighton Orr, *Vice-Chairman.*

Transportation Committee—D. W. Loucks, *Chairman;* Herbert A. Canon; George G. Waters.

Inspection Committee—Raymond J. J. Tennant, *Chairman;* Frank N. Speller.

Ladies Committee—Mrs. John F. Collins, Jr., *Chairman;* Mrs. Ferry C. Houghten, *Vice-Chairman;* Mrs. Clark M. Humphreys; Mrs. Robert A. Miller; Mrs. Fabian C. McIntosh; Mrs. Arthur F. Nass; Mrs. Leighton Orr; Mrs. Ralph B. Stanger; Mrs. Theodore F. Rockwell; Mrs. Raymond J. J. Tennant.

Entertainment Committee—Ralph B. Stanger, *Chairman;* Herbert A. Canon; Clark M. Humphreys; H. Lee Moore; Raymond J. J. Tennant.

Banquet Committee—Edward C. Smyers, *Chairman;* J. Edward McLean, *Vice-Chairman;* Mrs. Robert A. Miller; W. A. Allen; K. C. Lewis; H. E. Lore; A. W. Marshall; C. E. Parks; P. C. Strauch; W. H. Reed, III.

E. Holt Gurney Speaks on Radio

At 3 p. m. Sunday, January 22, E. Holt Gurney spoke from station KDKA, Pittsburgh, as guest speaker on the Armco Hour, over a Coast-to-Coast hook-up.

Good afternoon, ladies and gentlemen:

Radio, rayon and streamlined trains—those marvelous products of modern science—sometimes claim air conditioning as a younger brother. But, as a matter of fact, air conditioning is a *Victorian* matter, fully described in a three-volume treatise of the year 1904.

Since then it has grown steadily in scope and importance, until today our lives are coming more and more under the influence of air conditioning. In theaters, stores, restaurants and railroad trains, we experience the comfort and exhilaration of controlled weather all the year round. Even the clothes we wear and the food we eat have in many cases been processed in plants equipped with air conditioning. And in our homes, too, air conditioning coupled with modern heating is making for comforts and convenience unheard of a few years ago.

In short, air conditioning is coming to be another "taken for granted" miracle of modern science. Yet, how few of us ever stop to think that all this has been brought about through constant research by scientists, engineers, metallurgists, physicians, bacteriologists, and public health experts. Each group deals with an important phase of the subject, their efforts coordinated through a centralized bureau for research established 20 years ago by the American Society of Heating and Ventilating Engineers.

Most casual observers think of air conditioning largely in terms of *cooling.* While this *is* one major phase of the work, it is far from the *only* one. A new chapter in *heating* likewise is being written—with humidity control, air purification and circulation all given their proper place in every modern installation in home, office, store and industry.

We are all beginning to realize that standards of cleanliness and purity must be applied to the air we breathe just as carefully as they are to the milk and water we drink. In the air conditioning industry we sense more keenly perhaps than others, the growing demand that such standards be maintained in every sort of building, or conveyance, public and private.

Controlled air in hospitals is making an important contribution to health and medical science; millions of hay fever sufferers see relief in air conditioning; railroads are making travel much more comfortable; and all of us know how pleasant air-conditioned theaters and restaurants are today. Industry sees air conditioning as a powerful ally in cutting costs and improving the quality of the products we buy.

These and many other contributions of modern air conditioning lead me, and my associates of the American Society of Heating and Ventilating Engineers, to regard the science of air conditioning as an important national influence, likely to play a big part in the coming years of prosperity that assuredly face this nation.

I thank you.

Many members who listened in sent messages of greeting and congratulation to Mr. Gurney.

On Business and Pleasure

Samuel R. Lewis and Mrs. Lewis of Chicago left New York February 4 on the French Line steamer Normandie for a tropical cruise to West Indies and South American ports.

Victor Kraminsky, Air Conditioning & Engineering, Ltd., of London, England, attended the 45th Annual Meeting of the Society in Pittsburgh and sailed for London on the Cunard White Star liner Aquitania February 4.

Past Pres. E. Holt Gurney and Mrs. Gurney of Toronto left New York February 16 on the S. S. Kungsholm for a 32-day trip to South America and West Indies ports.

Walter L. Fleisher, consulting engineer, of New York, sailed for London on the Cunard White Star liner Aquitania February 18 for a four weeks' trip. While in England he will address a meeting of the *Institution of Heating and Ventilating Engineers,* on March 1.

Also en route home on the Aquitania are Mr. and Mrs. J. J. Fraser of London. Mr. Fraser is director of Honeywell-Brown, Ltd. and returns to England after a six weeks stay in the United States, which he spent at the various plants of Minneapolis-Honeywell Co. Mrs. Fraser is making her thirty-first crossing of the Atlantic.

J. K. M. Pryke and Mrs. Pryke returned to England on the Queen Mary, February 10, after spending four weeks in the United States. Mr. Pryke combined business and pleasure and investigated some of the most recent developments in air conditioning practice during his visits in Buffalo, Cleveland, New York and Toronto.

Michigan Chapter Enjoys Inspection Trip

January 16, 1939. The members of the Michigan Chapter were the guests of the Detroit Edison Co., for the regular January meeting, which was held in the general offices of the company, with an attendance of 125 members and guests.

Immediately following dinner, there was an inspection trip through the new Service Building, which proved very interesting. At the completion of the inspection trip, J. H. Walker, assistant to general manager, Detroit Edison Co., gave a very instructive talk in the auditorium on Some of the Interesting Features of the New Building, which was enthusiastically received and discussed by the members and guests. The meeting was brought to a close with a feature movie entitled, Test Pilot.

Western New York Chapter Meets

January 9, 1939. The January meeting of the Western New York Chapter was held at the University Club with 31 members and guests in attendance.

Following the reading of the minutes of the November and December meetings, Pres. J. J. Landers expressed his appreciation to Joseph Davis, C. A. Gifford and D. J. Mahoney for their successful efforts in arranging the Christmas party.

Mr. Gifford then announced that plans for the February meeting included three speakers to cover three types of domestic heating.

Roswell Farnham and Mr. Davis announced plans for the Annual Meeting in Pittsburgh.

President Landers appointed the following to serve on the Membership Committee: L. P. Saunders, chairman, V. P. John, H. C. Day, M. E. Kessler and T. I. Messenger. Those appointed on the Program Committee by President Landers are: C. A. Gifford, chairman, C. A. Reif, Herman Seelbach, Jr., Arnold Kamman, E. R. Walker and W. S. Eisele.

After the appointment of the committees President Landers introduced the speaker of the evening, L. P. Saunders, chief engineer, Harrison Radiator Co., whose subject was The Automotive Engineer Analyzes the Heating and Cooling Problem. Mr. Saunders explained in detail the design and test problems in connection with automobile cooling systems, giving the test procedure and the various results obtained. The members and guests showed considerable interest in Mr. Saunders' talk, as evidenced by the numerous questions asked at the conclusion of the meeting.

LET'S "SELL" OUR SOCIETY

There are many engineers who believe that we should not try to "sell" membership in the Society. With those, I disagree because selling is always dignified if it is done properly and if the object sold is worthy.

Membership in our Society is certainly worthy as is evidenced by some of the men who are joining, because, as they put it, our Society is getting results.

I was greatly impressed at the Pittsburgh meeting by one outstanding thing—the respect in which our research work, our research laboratory, and our research director are held by scientists of repute who are collaborating with our Society and our research committee in special research projects.

We are a fraternity dedicated to Research, to the dissemination of authoritative and up-to-date information adding to the sum total of human comfort.

We can be proud of our Society, and what it has done and is doing. When we invite a man to join, we are not asking a favor; we are offering him an opportunity to participate in a great work that is being done without thought of reward by a loyal and enthusiastic membership, and we are offering him personal benefits far in excess of the cost.

For a member to "sell" membership, in the dignified sense of the word, not only serves your Society, but it does the prospective member a favor. Let's "sell" membership to those who need it.

E. K. Campbell, *Chairman*
Membership Committee, ASHVE

Domestic Hot Water Heating Forum at Toronto

February 6, 1939. The regular meeting of Ontario Chapter was held in the Royal York Hotel, Toronto, at 6:30 p.m. with 77 members and guests present.

Following dinner, Secy. H. R. Roth read the minutes of the preceding meeting and gave his report on the Chapter delegates' meeting at Pittsburgh. It was moved by C. Tasker and seconded by Mr. Fox that the minutes and report be accepted as read.

It was moved by G. A. Playfair and seconded by M. W. Shears that J. H. Fox be chairman of the On to Mackinac Island Committee for the Semi-Annual Meeting of the Society to be held July 4, 5 and 6, 1939.

Pres. H. B. Jenney introduced visitors, who were attending the meeting.

H. H. Angus, chairman of the Open Forum on Domestic Hot Water Heating, was presented by President Jenney. Mr. Angus outlined pertinent data pertaining to domestic hot water heating. A film of various types of automatic control for domestic hot water heating was shown by Mr. Fox, which was followed by a discussion led by A. T. Jones and Mr. Strain of Hamilton.

Mr. Tasker extended a vote of thanks to Mr. Angus on behalf of the Chapter for the interesting meeting.

Before adjournment, President Jenney announced the Nominating Committee, which was selected by the Board of Governors, Mr. Angus, chairman, W. R. Blackhall and Mr. Shears.

Meetings of Philadelphia Chapter

February 9, 1939. The regular meeting of the Philadelphia Chapter was held at the Engineers Club. Fifty-one members and guests attended the dinner preceding the meeting.

The minutes of the previous meeting and the Treasurer's report were read and approved.

Edwin Elliot reported several new national members who are expected to affiliate with the Chapter in the near future.

R. F. Hunger then reported that the March meeting will be an inspection of one of the large industrial plants in Philadelphia. L. P. Hynes then called attention to the Hobby Show at the Engineers Club this month.

A committee consisting of L. P. Hynes and A. J. Nesbitt was appointed to draw up a resolution on the death of Warren Webster, Sr.

M. F. Blankin gave an interesting resumé of the Annual Meeting in Pittsburgh.

It was then moved and seconded that the recommended changes in the By-Laws be adopted and sent to the Society's Council for approval.

F. D. Mensing spoke on the subject of incorporating the Philadelphia Chapter ASHVE. It was moved and seconded that a committee be appointed to consider the advisability of incorporating and report back at the next meeting; the committee to consist of Messrs. Blankin, Chairman; Culbert, Eastman, Davidson, and Mensing.

H. R. Disston then spoke on the United Campaign and requested the active support of the Chapter.

President Erickson then introduced R. E. Daly who spoke on the subject of Modern Boiler Design. Mr. Daly presented a very interesting talk and pointed out many problems that are inherent in the design of residential furnaces for automatic fuels. After an extended discussion, the meeting adjourned at 10 p.m.

January 12, 1939. The annual meeting of the Philadelphia Chapter was held at Kugler's Restaurant. Dinner was served at 6:30 p. m. with 104 members and guests in attendance.

The meeting was called to order at 8:00 p. m. with Pres. H. H. Erickson presiding. The reading of the minutes and all other regular business was suspended to permit time for the more urgent business of the evening.

L. P. Hynes made a brief announcement of the recommendations of the special advisory committee on recommended changes in the By-Laws. It was moved and seconded that the recommendations be printed and sent out to the membership.

Following this action an accomplished master of ceremonies presented the entertainment, which was enjoyed by all present according to the report of Secy. H. H. Mather.

CANDIDATES FOR MEMBERSHIP

The Constitution of the Society, as now amended, requires the following mode of procedure in voting on applicants for membership in the Society. All applications for membership are to be sent to the Secretary and the names of applicants and their references shall be printed in the next issue of the JOURNAL of the Society or sent to the members in other approved manner as ordered by the Council. When replies are received from references, the Candidate's application shall be submitted to and acted upon by the Committee on Admission and Advancement as soon as possible.

When the Committee on Admission and Advancement has acted favorably upon a Candidate's application and assigned his grade, the Council shall vote upon the election of the proposed Candidate for membership by letter ballot. During the past month 28 applications for membership have been received and the names of these men and their sponsors are published in the following list.

Members are requested to scrutinize the list with care. The Committee on Admission and Advancement, and in turn, the Council, urge the members to assume their share of responsibility of receiving these candidates into membership by advising the Secretary promptly of any whose eligibility for membership is in any way questioned.

All correspondence in regard to such matters is strictly confidential, and is solely for the good of the Society, which it is the duty of every member to promote.

Unless objection is made by some member by March 15, 1939, these candidates will be balloted upon by the Council. Those elected to membership will be notified by the Secretary immediately after election.

CANDIDATES	REFERENCES	
	Proposers	*Seconders*
ARMOUR, E. G., Student, Carnegie Inst. of Technology, Pittsburgh, Pa.	C. M. Humphreys	J. F. Collins, Jr.
BENSEN, C. L., Chief Engr., McQuay, Inc., Minneapolis, Minn. (*Advancement*)	T. F. Rockwell	M. L. Carr
BLIZZARD, B. C., Asst. Mgr., Fuel Oil & Burner Dept., Imperial Oil, Ltd., Toronto, Ont., Can.	F. B. Rowley	R. C. Jordan
BROWN, M. L., Vice Pres., Dallas Air Cond. Co., Inc., Dallas, Tex.	A. B. Algren	E. H. Seelert
BUZZARD, F. H., Asst., C. S. Leopold, Cons. Engr., Philadelphia, Pa.	J. H. Fox	W. R. Blackhall
CARNEY, E. J., Htg. Contractor, John C. Kohler Co., Philadelphia, Pa.	H. H. Angus	H. R. Roth
CLARK, R. L., Pres., Clark Asbestos Co., Cleveland Heights, Ohio (*Reinstatement*)	T. H. Anspacher	H. J. Martyn
CLAUSEN, A. H., Air Cond. Engr., Edward B. Ward & Co., San Francisco, Calif.	R. B. Taylor	C. R. Gardner
CROMBIE, JAMES, Sales Engr., Fox Furnace Div., Elyria, Ohio	E. H. Dafter	W. L. Yerkes
DAVIS, G. C., Vice-Pres., Northern Public Service Corp., Winnipeg, Man., Can. (*Advancement*)	C. S. Leopold	David Ladd
FLORETH, J. J., Mgr., Air Cond. Div., Westerlin & Campbell Co., Chicago, Ill.	Edwin Elliot	E. K. Wagner
FROELICH, H. A., Gen. Mgr., The Glen Aire Cooler Co., Junction City, Kans.	W. P. Culbert	David Ladd
HOFFMAN, HARRY, Br. Mgr., Johnson Service Co., Greensboro, N. C.	L. S. Ries	J. H. Ferguson
HUTCHINSON, B. L., JR., Engr., York Ice Machinery Corp., Cincinnati, Ohio	E. W. Gray	D. L. Taze
KEITHLEY, F. R., Sales Engr., Malvin & May, Inc., Chicago, Ill.	C. E. Bentley	G. M. Simonson
KOHLER, J. C., Partner, J. C. Kohler Co., Philadelphia, Pa.	James Gayner	N. H. Peterson
LEWIS, H. E., Engr., Eagle-Picher Sales Co., Cincinnati, Ohio	J. E. Maynard	C. W. Helstrom
McRAE, M. W., Engr., Crane Co., Chicago, Ill.	V. B. Kofoed	A. G. Kalinsky
MUCKLE, JAMES, Dept. Mgr., Andersen, Meyer & Co., Ltd., Shanghai, China	William Glass	R. L. Kent
NICHOLLS, J. M., Mgr. Engrg. Dept., Robbins Gamwell Corp., Pittsfield, Mass.	J. B. Steele	William Worton
OSBORNE, S. R., Br. Mgr., B. F. Sturtevant Co., Albany, N. Y.	M. W. Bishop	J. E. McClellan
REIS, ROBERT, Engr. & Estimator, Reis & O'Donovan, Inc., New York, N. Y.	H. G. Chapin	J. F. Tobin
REISBERG, L. K., Vice-Pres., Goodin Co., Minneapolis, Minn.	E. K. Campbell	C. A. Flarsheim
SCHUBERT, A. G., Asst. Prof. Mech. Engrg., Rensselaer Polytech. Inst., Troy, N. Y.	I. E. Matthews	A. D. Marston
SPALL, E. G., Sales Engr., Penn. Electric Switch Div., Toronto, Ont., Can.	H. H. Hill	M. F. Rather
STIRLING, W. N., Tech. Repr. for India, Messrs. J. & E. Hall, Ltd., Dartford, Kent, England	E. H. Brandt, Jr.	F. E. W. Beebe
TRIBBLE, W. L., Mgr. & Engr. of Htg. & Air Cond., Southern Air Cond. Corp., Jacksonville, Fla.	Anker Winther	G. V. Sutfin
WELLS, W. F., Asst. Prof. Sanitary Engrg., Univ. of Pennsylvania, Philadelphia, Pa.	R. E. Kramig, Jr.	H. E. Sproull
	R. C. Malvin	F. J. Lilld (*Non-Member*)
	M. F. May	W. T. Hooper (*Non-Member*)
	Edwin Elliot	E. K. Wagner
	W. P. Culbert	David Ladd
	Anker Winther	G. A. Young
	W. T. Miller	Douglas Via
	I. F. McIntire	L. N. Hunter
	M. K. Fahnestock	R. E. Daly
	T. F. Waung	R. L. Stinard
	O. O. Oaks	S. A. Groves
	W. A. Russell	W. K. Simpson
	C. W. Stewart	R. H. Gamwell (*Non-Member*)
	E. V. Evans	J. F. G. Miller
	H. A. Bond	R. E. Reid (*Non-Member*)
	E. A. Bennett	W. E. Heibel
	F. R. Still	O. O. Oaks
	A. B. Algren	R. C. Jordan
	H. M. Betts	F. B. Rowley
	E. A. Fessenden (*ASME*)	W. O. Hotchkiss (*Non-Member*)
	G. K. Palsgrove (*ASME*)	A. E. Cluett (*ASME*)
	A. H. Hills	J. J. Lawlor
	A. T. Jones	H. R. Roth
	B. T. Benson (*AIEE*)	H. Bentley (*ASME*)
	T. C. Lahiri (*MIE*)	R. G. Trusler (*ASRE*)
	W. C. Armistead	C. B. Cole
	A. J. Edge	Leo Sudderth, Jr.
	F. C. Houghten	Philip Drinker
	C. P. Yaglou	E. K. Campbell